America's First Aeronautical Magazine

AVIATION

JANUARY 1947

50 CENTS PER COPY

IN THIS ISSUE

DESIGN DETAILS OF THE MARTIN 202

On-the-spot study reveals numerous construction innovations and servicing timesavers incorporated in latest twin-engine airliner.

★

ROTATIVE FLIGHT BRAKE AIMS TO EASE LANDINGS

Southwest Airways' James G. Ray submits method to moderate set-down speeds by permitting rapid variations in drag.

★

RMI'S ROCKET ENGINE WHICH POWERS XS-1

Liquid propellant regenerative plant develops upward of 6,000 lb. thrust, employs positive-start injector, and being relatively small and light features ease of installation

★

"OPERATION TURTLE" SPARKED BY DESIGN

"Tailor-making" the type turned the trick. Thus Lockheed's Navy P2V met exacting patrol plane requirements — and spanned the globe to give proof in performance.

McGRAW-HILL PUBLISHING COMPANY, INC.

AVIATION

CONTENTS FOR JANUARY, 1947

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Cold Realism for 1947

A YEAR OF READJUSTMENT has just passed, and with it the benevolent provisions of the tax carry-back. The aviation industry is once more on its own. Although it is far better off than it was after World War I, the acid test for many manufacturers will come in 1947. It is time to be coldly realistic about the aviation business.

In spite of soaring personal plane production and the overpowering demand for transport aircraft in 1946, the civil airplane market is still much smaller than the military in terms of dollar value. There appears to be no immediate prospect of reversal of this situation. As duplicate orders are weeded out and as the need for training planes and airliners is satisfied, the preponderance of military business is still further emphasized.

Some manufacturers have been slower than others to realize the deflated position of the industry and what it means in terms of their individual companies. It is their responsibility to strive continually for more efficient operation on the existing scale of activity. But no man can plan his business intelligently if he has one customer whose needs vary with changing public attitude toward the national security. Never before has it been so important that we evolve and implement a national air power policy—and without further delay.

A long time ago the Air Coordinating Committee set 3,000 military planes per year as the minimum production for preservation of the industry in a state of readiness for quick expansion. Even this low figure presupposed a year of grace before an enemy attacked us. In the past two wars, this period of grace was the beginning of defeat for our enemies. No aspiring dictator will again make the mistake of allowing us that time concession.

In the past year, production fell far below the 3,000 plane minimum. The industry was able to carry on largely because of the carry back. But the industry seeks no subsidy. All that it asks is a sufficient volume to keep going at a safe level for national security.

It is the grave responsibility of the new Congress to consider these facts and figures and the proposals to preserve plant facilities and pilot-line production. To provide these necessities in the face of high pressure for economy is a Herculean task, but it is a fundamental and immediate requirement for national security. In the long run the minimum level of military aircraft manufacturing can be obtained most economically by long term planning under a sound air policy.

Microscope Those Markets

PART OF THE PRESENT PLIGHT of personal plane makers is their failure to know their markets and to plan accordingly. In the pressure of unprecedented demand, little if any thought has been given to what kind of people were buying their products. This is a fundamental mistake in any business.

The personal plane production peak came later than that of military business. When the present confusion clears away, we may expect a growth curve above the prewar level, but bearing little relation to the 1946 figures. Retrenchment problems faced by military builders last year have now descended upon the personal plane makers. And other problems have been added, too.

First job for the long winter evenings is a searching study of the personal plane market, and its relationship to national economic conditions. Others include tightening up of manufacturing operations and revamping of distribution setups. For use in the latter, AVIATION'S surveys, "Here are Your Markets" and "Here are Your Local Markets" are available and will still be valuable even though they were published some time ago. Knowing your customers and learning how best to serve them are the first steps in any successful business.

Leslie E. Neville

EDITOR

What's New
In Products and Practices

. . . Key facts on the latest devices and equipment, tools and materials, product-and-practice literature. For additional data on any item, or copies of literature, simply fill in handy form (page 13), clip it to your letterhead and mail to AVIATION Reader's Service. There is no cost, no obligation.

Aircraft Electric Wire 1

Developed to reduce fire hazard and lighten weight of planes, new aircraft wire known as "Neolay", announced by **United States Rubber Co.**, New York City, is reported to be 30% lighter than conventional electrical wire. Insulation, said to be flameproof, consists of a layer of glass fiber to insure circuit integrity and a fire-resistant synthetic rubber applied by a special dipping process. Overall dia. is 15% smaller than regular aircraft wire. Tests show it to resist oil, chemicals, mildew, and fungus.

Small Plane Battery 2

Designated as Type AW-12-25, new small-craft battery has been developed by **Willard Storage Battery Co.**, Cleveland, Ohio, to have more power, lighter weight, higher performance, and longer life. It is a 12v. unit with outside dimensions 10 x 5¼ x 7¾ in. Capacity is given as 26 amp.-hr. at 5-hr. rate. Other improvements reported by maker are: Cold starting performance raised, internal discharge reduced, improved protection against acid spray or spillage, and weight cut to 23.5 lb.

Motor-Generator Set 3

Having both motor and generator mounted on same shaft, new motor-generator set designed for such aircraft ground applications as supplying power for radio and radar test work, or supplementing batteries for plane engines, has been announced by **General Electric Co.**, Schenectady, N. Y. Set is a 200-amp. 3600-rpm. unit with generator rated 150 amp. maximum for 1 min. in either 28.5 or 15v. designs. Motor is induction type, 3 phase, 60 cycles, and can be designed for any standard a.c. low voltage supply. Control equipment includes an aircraft-type voltage regulator and reverse current relay, a line switch, load terminals and a motor starter. Voltage regulator provides an equalizer connection for parallel operation, and reverse current relay affords protection from reversal of generator current when two or more machines are operating in parallel. When operating with batteries, it connects generator to line at proper generator potential and disconnects it when current is flowing from batteries to generator,

preventing generator from running as a motor in case generator voltage becomes lower than battery voltage. Manual across-line starter has thermal overload protection.

Shut-Off Valve 4

Wm. R. Whittaker Co., Los Angeles, announces that its new aircraft sliding gate shut-off valve, developed for use in civil and military aircraft, has been approved by CAA as fireproof. During tests, valve was subjected to flame tem-

peratures of 2000 deg. F. It consists of two ported metal face plates between which a metal slide operates against synthetic rubber rings. Valves are made in various types, sizes, and pressure ratings to meet requirements of aircraft installations and are suitable for fuel oil, engine oil, water, air, or vacuum lines. Adaptable to remote control systems, they are being installed on Convair 240, Douglas DC-6, Boeing Stratocruiser, and Lockheed Constellation.

Portable Oxygen Equipment 5

Available in 120 and 202 liter capacities, portable oxygen equipment made by **Scott Aviation Corp.**, Lancaster, Pa., has flow regulating orifice built into

outlet fitting. Formed of a glass wool pad, it is non-freezing type. Three standard sizes are available for minimum flows of 2, 3, and 7 liters per minute flow ratings at 20000 ft. altitude. Limited range of adjustments can be obtained from regulator pressure setting, but major changes must be made at factory. Recharging is handled by cascading standard commercial oxygen cylinders and using recharging fittings. Unit is designed to operate with standard constant-flow rebreathing type masks.

Airport Snow Plow 6

Equipped with a specially designed feeding rake permitting rotary to work in snow 2 in. to 12 ft. deep, new rotary snow plow, "Sno-Flyr", is announced by **Wm. Bros. Boiler & Mfg. Co.**, Minneapolis. New type gathering wings and

safety shear pins attached to 8-ft. plow frame allow an overall cutting width of 14 ft. These wings collect snow to within ½ in. of runway surface and force it into double rotary wheels. Rotary blades and feeding rake pulverize different types of snow and ice into a consistency that permits casting 150 ft. either side of runway. Rotary wheels are powered by an 8-cylinder 275-hp. gasoline motor mounted on rear of 7-ton 4-wheel-drive truck. As snow leaves blades, it passes through a newly designed chute and deflector that prevents formation of ridges behind landing lights. Plow, feeding rake, and wings are hydraulically controlled from cab. Gathering wings may be individually lifted up to a clearance of 18 in. from runway. This control is to permit collecting snow behind and between landing lights and allows wings to clear snow off these lights. Casting capacity of this plow is stated to be 51-tons of fresh snow per minute. A loading chute may be attached if desired.

Small Range-Receiver 7

Suited to smaller types of personal aircraft that are not equipped with storage batteries, PAR-3 range receiver is announced by **Bendix Radio Div., Bendix Aviation Corp.**, Baltimore, Md. Requiring only antenna (connection is provided through bottom of case), it is operated from standard 67½v. (6.5 ma.) "B" and 1½v. (0.25 ma.) "A" batteries and can be used for airport traffic control, student control, cross-country

radio range avigation, and weather reports. Unit is a 3 11/16 in. cube weighing about 1½ lb. A 5-ft. twisted cable lead is provided with battery connectors. Tuning range is 195 to 410 kc. Circuit is a 4-tube superhetrodyne, using an intermediate frequency of 455 kc. Sensitivity is said to be 8 mv. for a 4-to-1 signal-to-noise ratio, selectivity 25 kc. total band width for 40 db. attenuation, and maximum audio output 125 mw., using 67½v. supply.

Avigation Protractor 8

Developed to eliminate need to independently figure interior and exterior angles and to simplify work, new protractor called "Plotractor" is announced by **Plastics Div., Monsanto Chemical Co.**, Springfield, Mass. Device's ability to compute its own angles from bearings is called a major innovation in basic protractor design. Made of plastic, instrument has an interior

rotor which revolves 360 deg and is calibrated same as surveyor's transit With vernier reading to 10 min, it not only can be used for azimuth plotting, but also eliminates use of parallel rules in aviation

Wheel Removal Dolly 9

Incorporating a welded tubular base movable on one swivel and two fixed casters, new hydraulic wheel removal dolly, for removing and installing landing gear wheels on multi-engined air-

craft, is announced by **Airquipment Co.**, Burbank Cal Wheel carriage fork is operated by a manual hydraulic jack. Dolly handles tires and wheels up to 65 in in dia A steel chain holds wheel in place when moving unit

Aircraft Valves 10

Available in needle and non-rising stem shut-off types in sizes up to 1 in, new series of aircraft valves announced by **Parker Appliance Co.**, Cleveland, Ohio, are made in both angle and offset designs and have forged aluminum bodies Both types are available in seven variations of connection arrangements Straight-line types are produced with female pipe threads or with AND-10056 flared tube coupling threads for use with seamless tubing Angle types are provided with female pipe threads, with tube threads, or with male pipe threads at inlet connection and either tube or female pipe threads at side outlet Angle and offset types are also furnished with AND-10050 straight thread bosses for 3 000-psi hydraulic systems. Tubing is accommodated in a range of from ¼ to 1 in outside dia, pipe from ⅛ to 1 in All valves are provided with integral mounting lugs for securing valves to panels or brackets

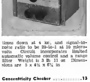
Landing Gear Cylinder 11

Featuring new kind of snubbing action, hydraulic landing gear actuating cylinder made by **Air Associates**, Teterboro N J, and developed for use with 3,000 psi hydraulic systems, is

designed to bring landing gear down at usual speed at start then slow action at last moment, cushioning gear so it locks into position without shock and resultant deflection. Developed for use with retractable landing gear, these readily adaptable cylinders are available in five sizes.

Aircraft Radio Receiver 12

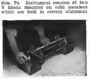
Featuring long range reception of broadcast band, as well as radio range stations, and airport control towers, new aircraft radio receiver, Ranger Model 120, designed for both speaker and headphone operation, made by **Electronic Specialty Co.**, Los Angeles has frequency coverage from 195 to 410 and 540 to 1580 kc. Unit is six tube superheterodyne, using an intermediate frequency of 150 kc. Its average sensitivity is said to be 2 microvolts for 1w output, average selectivity to be 2



times down at 4 kc, and signal-to-noise ratio to be 20-to-1 at 10 microvolts Circuit incorporates limited automatic volume control and a range filter Weight is 3 lb 11 oz Dimensions are 5 x 4½ x 6¼ in

Concentricity Checker 13

Designed to automatically determine proper center-line heights required for any combination of diameters involved in a work piece—by turning a compensated screw which raises vertically adjustable V block—new concentricity checker, "V-Liner", is made by **Swanson Tool & Machine Products, Inc.**, Erie, Pa Instrument consists of two V blocks mounted on solid members which are held in correct alignment



by cylindrical rods These hardened and ground aligning rods are pressed into first V block member and permit second V block member, with elevating V block to move as desired Both blocks have replaceable hardened and ground tool steel wear edges Hardened adjusting screw and bronze nut, raising or lowering movable V on guide pins, is calibrated and compensated for sine of V. Pieces are checked by

setting adjusting screw in accordance with graduations indicated thereon to correspond to diametrical difference between any diameter involved It will check concentricity of internal and external diameters, and determine concentricity of shafts of varying bores, counterbores, and outside diameters. It may also be used for positioning parts on light milling, drilling, and surface grinding operations.

Portable Welder 14

Incorporating a welding generator in a Jeep, new portable welding unit is announced by **Welding Engineering Co**, Milwaukee. Unit consists of a 200-amp welding generator connected by V-belts to a power take-off inside car It has a 15-250 range and is equipped with 100 ft cables

Remote Control Servo Mechanism ..15

Consisting of torque unit, amplifier unit, and control unit (as pictured, left to right), new servo mechanism for remote control or indication made by **G C Wilson & Co**, Chatham, N J, operates from 115v 60-cycle power, which

is supplied by amplifier Position of shaft on torque unit is controlled by amplifier to correspond to control unit System is said to be sensitive to 1% change in control unit which requires about 1 oz-in of torque for operation Torque unit develops a maximum of 50 lb-ft. of torque Amplifier consists of three radio type vacuum tubes and associated equipment. Safety feature provided on control unit is a signal light which indicates correct operation of system

Portable Lighting Units 16

Built around a 5,000w Westinghouse self-excited, self-regulated a.c generator driven by a 15-hp 4-cylinder air-cooled engine, four new "Da-V-Lite" portable lighting and power units have been announced by **Davey Compressor**

Co., Kent, Ohio Suitable for use on airfields, standard models are Floodlight, searchlight, combination, and beacon All are available in skid and 2-wheel trailer mountings. Floodlight models are equipped with four heavy duty 18-in lights each providing 185-000 cp Each light is individually operated from control panel and can be raised 8 ft 8 in Searchlight models are equipped with two 18-in search-

(Turn to page 127)

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AIRPLANE propellers were asking for trouble as they whirled through the air in certain weather conditions. Their leading edges, biting into supercooled moisture droplets, quickly gathered ice—thrust was not maintained, and full engine power wasn't available. Now B. F. Goodrich has developed a heated rubber shoe that concentrates warmth where protection is needed.

This rubber is made in a thin, tough "skin" which fits tightly over almost any regular or irregular shape. Current from a lightweight generator produces heat in the "skin." Resistances are carefully planned so the heat can be closely controlled. Just the right amount of heat reaches just the right places.

Instrument masts, engine cowls, spinner domes and other exterior applications receive enough heat to keep ice from forming. On hydraulic lines, water tanks and other special interior parts, heated rubber "jackets" can be utilized to prevent freezing and maintain flexibility.

Besides the cold weather advantages, these B. F. Goodrich rubber "skins" on exterior accessories offer excellent abrasion-resistance . . . sturdy protection against sand, pebbles, cinders, and the eroding effects of rain—especially important to propellers. Perhaps heated rubber can help you. For facts, write to *The B. F. Goodrich Co., Aeronautical Division, Akron, Ohio.*

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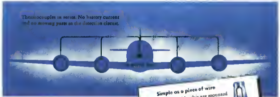

Simple as a piece of wire

Thermocouples like this are mounted in potential fire zones. Each is just a piece of wire connected in series. Only a fire can make it send an alarm signal.

Only EDISON makes the thermocouple type

How EDISON thermocouple fire detection meets ideal requirements

[ITEM VIII-A-1 OF REPORT NO. 2 *of Aircraft Industries Association ARC Subcommittee on Aircraft Fire Detection Airworthiness Project No. 7, dated May 27, 1946, lists requirements for the ideal fire detector. See how the performance of the Edison system compares with these ideal requirements.*]

The IDEAL Detector (From ARC Report)

"**a.** Should be ruggedly constructed so as to resist exposure to gasoline, oil, dirt, water, vibration, fatigue, salt air, and handling.

"**b.** Detector circuit should require no current until the actual alarm has signalled, unless a supervisory system is used.

"**c.** It should fail safe, i.e., in case of circuit failure it becomes inoperative rather than give a false alarm.

"**d.** A test button should be provided to check the entire system.

"**e.** There should be no moving parts in the circuit.

"**f.** The detector should be able to withstand more than one fire without having to be replaced or calibrated.

"**g.** The detector should indicate when the fire is extinguished."

The EDISON Detector

a. It is RUGGED and AMAZINGLY SIMPLE . . . just a piece of wire that is mounted in each potential fire zone . . . that's all there is to a thermocouple.

b. Thermocouple detectors require no battery current. They generate their own current, and they send a "FIRE" signal *only when there is a fire.*

c. Should a thermocouple circuit fail, it could send no signal . . . couldn't give a false alarm.

d. The push of a button checks the entire Edison system.

e. There are no moving parts of the system in the fire zones. The only moving parts are the relay contacts located in the signal system.

f. Thermocouple detector will withstand many fires without need for replacement or calibration.

g. A thermocouple detector signals "FIRE OUT" and is again ready to signal "FIRE" after conditions return to normal.

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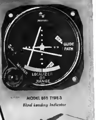

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● In 1917, when the airplane was receiving its baptism of fire as a weapon of war and aerial transportation of men and merchandise was most primitive, BG began the manufacture of aviation spark plugs.

Today, BG RB19R ceramic-insulated aviation plugs spark the ships on air lines providing passenger and freight service on every continent and across all the seas of the globe.

Efficiency, economy, long service life, dependability, and quality are the reasons why BG spark plugs have attained this position. And back of all are the unceasing research and development at BG which have kept pace with every advance in aviation.

BG spark plugs are also firing jet propulsion engines and aviation gas turbines, both in actual flight installations and in experimental projects.

As we make note of our thirtieth year in aviation, we wish to express our deep appreciation to those in the industry with whom we have pioneered and whom we have been privileged to serve.

THE BG CORPORATION
136 West 52nd St., New York 19, N. Y.
MANUFACTURERS OF BOTH CERAMIC-INSULATED AND MICA-INSULATED AVIATION SPARK PLUGS

Gleam in the Eye of a Navy Cadet

From the moment a Navy flying cadet arrives at his flying field barracks, his eyes and his heart are on "the line."

For there rests his first love, the plane in which he will learn many of the precise and efficient practices of Naval Aviation.

A new plane for "the line" at Naval training stations has flown its first tests—a primary trainer that looks and "feels" like the shipboard fighters some of the cadets will eventually fly.

Sleek, clean-lined, powerful, and with new safety features, this latest product of Fairchild design and engineering development is the XNQ-1. It embodies flight and safety characteristics never before attained in a plane of this type—characteristics that a farsighted Navy specified for the ideal training airplane.

Careful research and engineering skill mark the XNQ-1, as they mark all Fairchild products, with "the touch of tomorrow." These engineering skills won for Fairchild the XNQ-1 contract in a competition among the nation's topflight designers—a competition sponsored by the Navy's Bureau of Aeronautics.

XNQ-1 Navy Specifications

- Tandem, 2-place, low-wing, all-metal monoplane.
- Flaps, retractable landing gear.
- Controllable pitch propeller.
- One-piece "bubble" canopy affording all-around vision.
- New, Navy-developed safety cockpit.
- Power plant—320 h.p., 9-cylinder Lycoming in a Fairchild-designed "power package."
- Speed—170 m.p.h.
- Rate of Climb—1,000 ft. per min.
- Stability and control of carrier-based aircraft

Fairchild Aircraft

Division of Fairchild Engine & Airplane Corporation, Hagerstown, Maryland

LIGHTEN MAINTENANCE OF HEAVY DUTY ENGINES

NICKEL CAST IRON

Look for dependable performance from these piston rings, even in service of the most severe sort.

They'll give you substantially more hours of operation along with commensurate savings in maintenance and replacement costs because of their high elastic properties and improved resistance to wear. Moreover, they maintain dimensional stability at operating temperatures and thus assure advantages of proper cylinder seal in heavy duty engine operation.

These vastly improved service properties stem from the development of two piston ring irons, alloyed with nickel, chromium and molybdenum.

TYPICAL PROPERTIES

	Standard Gray Iron for Piston Rings	F-37	F-95
Tensile Strength, p.s.i.	41,200	72,400	108,800
Rockwell Hardness	101(B)	30(C)	33(C)
Brinell Hardness*	248	285	311
Elastic Modulus, p.s.i.	11.9×10^6	$17.-18. \times 10^6$	$22. \times 10^6$
Modulus of Rupture, p.s.i.	—	117,000	190,000
Izod Impact** (inch-pounds)	3	5	10/15

*By conversion.
**Comparative values obtained from breaking .14" x .26" x 3.0" bars in an inch-pound Izod test machine.

The Wright "Cyclone," shown above, is one of many leading types fitted with F-37 Nickel alloy iron piston rings.

Designated as F-37 and F-95, these modern ring materials of heat-treated gray iron were developed by the American Hammered Piston Ring Division of Koppers Company Inc.

Nickel may be the answer to problems that confront you. When you need material for tough jobs . . . think of Nickel.

EMBLEM OF SERVICE INCO Nickel

Over the years, International Nickel has accumulated a fund of useful information on the fabrication, treatment and performance of alloys containing Nickel. This information and data is yours for the asking. Write for "List A" of available publications.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

THE AVIATION NEWS

» **Production Report**—Despite reconversion difficulties early in 1946 and chronic materials shortages since, the aircraft industry seems to have justified earlier predictions as to its expected 1946 output—in numbers if not in value

By the end of October, latest month for which Census Bureau official figures are available, planes produced totaled 31,013, as against a mid year estimate that 1946 production would be about 35,000 Value through October was slightly more than $300,000,000, which indicates a disappointment, since the original hope was for a billion-dollar year, about 60% military and 40% civilian But the figure through October included military, although not experimental and development work

Chief difference in estimates and performance has been delay in deliveries of large civilian types and military planes Through October, military and naval deliveries totaled approximately 1,100 planes That deliveries were behind did not deter AAF from letting probably largest contract since the war—to Republic for about 500 P-84 jet fighters at approximately $25,000,000

If production is not living up to some hopes, development gives every indication of so doing Navy took the wraps off two new jet fighters, NAA's XFJ-1 and Chance Vought's XF6U-1 (see page 65), while further information seeped out on the combination jet-reciprocating four-engine Martin XP4M-1 bomber for the Navy, which already has flown The Martin is a high-wing plane with two nacelles, each housing a P&W Wasp Major engine and an I-40 jet Gross weight is 81,887 lb and top speed 398 mph

Development on the commercial side also kept apace Martin's 202 is said to have justified its manufacturer's every hope in its first test flights, and deliveries are expected to begin to airline customers this month Although Boeing decided to discontinue work on its 417 feederliner Curtiss Wright announced plans for a new cargo plane, the CW-32, on which engineering has begun

» **New Life for NATA**—After several years of trying to effect a strong reorganization, National Aviation Trades Assn. came up with the most promising plan yet—state associations bound together in a national federation New president is Beverly Howard, pres Hawthorne Flying Service, Orangeburg, S C, one of the country's leading operators Offices will be in Washington, D. C, in charge of Harry Meixell as executive director A new financing arrangement with assessments based on per capita wealth and state populations, is calculated to raise $40,000

» **Guinea Pig**—The aircraft industry is being used as the proving ground for Army and Navy industrial preparedness plans, it has been officially acknowledged by Richard R. Deupree, chairman of the overall coordinating agency, Army-Navy Munitions Board For the fiscal year beginning next June, Army and Navy will ask a total of $70,000,000 to give out to the industry on contracts to prepare plans and pilot tooling for mass production of specified types of aircraft

Each year, the industrial preparedness plan will be revised to keep it up to date and enable the industry to attain mass production status in relatively short time Emphasized is the two-year or more lag in World War II before this country reached the mass production stage —with warnings that such time will never be given the U S again Thus the necessity to prepare now AAF and Navy already have given selected manufacturers small contracts to study production processes and submit ideas on which the overall plan can be formulated

« **Congressional Expectations**—Belief grows that the 80th Congress will make at least two major changes in the aviation picture One has to do with surface carriers, considered by many Washington observers to be facing a golden opportunity to push through legislation that would allow them to wedge into air transport This is based on the indicated tie-up between the House Merchant Marine Committee, which has been on record for a long time in favor of sea-air operations, and House Interstate and Foreign Commerce Committee, whose new chairman, Rep Charles Wolverton (R., N J.), advocates transportation integration permitting railroad air operations

Odds are heavy that the new Republican Senate will require all bilateral executive air agreements to be made in the form of treaties, subject to approval by a two thirds Senate vote, regardless of the effect this may have on agreements of this kind already effected by the Administration Sponsors of the airport program have braced themselves in anticipation of heavy cuts in appropriations by an economy-bent Republican Congress

« **Radar Reward**—NAA has awarded the Robert J Collier Trophy to Dr. Luis W. Alvarez, developer of the Ground Control Approach radar landing system. With GCA, a pilot is "talked" down, with a controller on the ground following the plane's course on a radar scope and giving directions to the pilot by radio

Because direction of the plane passes from the pilot in the cockpit to men on the ground, many pilots are reported to oppose GCA, while CAA favors its own radio-operated Instrument Landing System because it costs less to install and, being automatic, requires no additional employees in control towers

AAF carefully tested both systems at CAA's experimental station in Indianapolis, using a C-54 and pilots

BENDIX READIES COMMERCIAL 'COPTER

Here's first photo of new Bendix four-place Model J which is to be marketed soon as testing and production-planning programs are completed Powered by a 450-hp P&W Wasp all-metal co-axial craft has fixed tricycle landing gear Six prototypes are scheduled to be built for proving Fin configuration is of special interest

XS-1 FLIGHT MARKS NEW AAF MILESTONE

Dwarfed beneath 141 ft span of Boeing B-29 mother ship carrying it aloft (top) for first powered flight Bell XS-1 supersonic research craft is seen (above left) rocketing away after having been released at 27,000 ft Company test pilot "Slick" Goodlin opened power gradually attaining trial speed of 550 mph. during 7-min flight at 35,000 ft He later declared confidence in craft reaching 1,500 mph designed top speed while AAF slates sonic speed attempts would climax test program running through spring Photo (above right) shows XS-1's rather simple instrument setup, limited to most essential devices (International-AAF photos)

from its own ranks, from CAA, and from airlines Not only did 70 of 75 pilots prefer GCA, but all made more accurate approaches, even fighter pilots with no previous GCA experience In fact, fighter pilots, with an average of only 805 hr, did better on GCA than far more experienced pilots, including airline captains, were able to do on ILS The airline pilots had a better record in the tests on CCA than they did on ILS

» **Pioneering in Cockpits**—Recent stories in the newspapers regarding U S British cooperation in development of their armed services have been foreshadowed by a joint AAF, BuAer, and RAF project to design a standardized cockpit First use of the new cockpit arrangement is in the Fairchild XNQ-1 trainer

Purpose of standardization is to enable any pilot of the three services to climb into any single-engine plane and know precisely where any particular instrument or device is located All Navy planes, for instance, will have the carrier arresting hook control in the lower right hand corner—and the control will be shaped like a hook so there will be no mistake Gun controls are always to the left and above the pilot, and so forth

» **Sales Trend**—Planes with more utility and customer appeal appear to be holding sales volume, even at higher prices, than minimum price planes NAA Navion, Stinson Voyager 150, Piper Super Cruiser, and Cessna 140 are probably doing best among planes now in production, while the four place Beech Bonanza and simplified-control Aeronca Chum are promising newcomers Companies with large dealer organizations appear to be weathering the slump in better fashion than those with distributor-dealer concentrations

» **Two Reorganizations**—Two principal prewar lightplane manufacturers, Taylorcraft and Culver, filed petitions for reorganization under Federal bankruptcy law

» **Helicopter Sales**—Sales of approximately 40 two-place helicopters costing about $1,000,000 announced by Bell Aircraft Corp included three to a Swedish firm and nine to Central Aircraft Corp, Yakima, Wash, for crop dusting and training They were the first quantity sales of commercially-licensed helicopters

» **New Helicopters**—Sikorsky announced that after flight tests are completed on the new S-52, an initial production of 300 is planned with price around $15,000 Quantum Research Corp, Paterson, N J, reports experiments with jet-driven helicopter, which uses rotor for takeoff then disengages rotor clutch for auto-rotation, propelled by the jet Meanwhile Wright Field disclosed experiments with the German built Doblhoff jet-propelled helicopter Propulsion comes from jet nozzles in the tips of rotor blades A conventional 135-hp engine drives a centrifugal supercharger compressing an air charge which is mixed with fuel and ducted through the rotor head to blade tip combustion chambers for ignition

» **Cargo Free-For-All**—A free-for-all in the air cargo field in the coming year was in prospect, following CAB's latest proposal for revision of the controversial nonscheduled exemption CAB asked comment on a suggested measure that would differentiate between airfreighters and uncertificated lines carrying passengers All-cargo lines with route applications pending would be allowed to operate on a scheduled common carrier basis until 60 days after disposal of their requests for certification Opposition to the suggestion will come from ATA and its scheduled airline members

» **Safety Record**—Airline safety record for first 10 months of 1946, when passenger deaths per 100 million passenger-miles flown numbered 1 2, equalled best previous record set in 1939 Figure for first ten months of 1945 was 2 6

» **Air Agreements**—Bilateral agreements effected by the U S with India, China, Australia, and New Zealand, gave diplomatic go-ahead to round the world operations by U S airlines and meant increased service to Orient and South Pacific. Airlines that have been certificated to the areas are PAA, TWA, and NWA

» **Canadian Notes**—Domestic Dominion airlines in Aug 1946 carried 76,000 passengers, almost double number carried in Aug 1945, according to preliminary figures of Canadian Air Transport Board, Ottawa Operating revenue was up 47 2% to $2,339,000, operating expense was $2,198,000 Total of 2,588,000 revenue-miles were flown That month Canadian domestic airlines employed 455 pilots and co-pilots, 2,422 ground crew, and 2,704 administrative and airport personnel, with total payroll of $1,055,000

TCA has designed a special drydock for servicing new DC-4M aircraft Feature of drydock is that it is built for indoor servicing in normal size hangars, with catwalk suspended from roof on monorail system for upper surface and tail assembly servicing Roof catwalk opens in two sections to allow aircraft to be placed in drydock

DESIGN DETAILS OF THE MARTIN 202

By **IRVING STONE**, *Assistant Editor "Aviation"*
With Field Sketches and Photos by **E. J. BULBAN**, *Editorial Assistant*

Many construction innovations and servicing time-savers are opponent in this on-the-spot study of latest twin-engine transport —now in production for airlines here and abroad.

An outstanding feature of the numerous engineering refinements embodied in the Martin 202 — new high-speed twin-engine transport — is the elaborate provision for low-cost maintenance. This consideration is not merely aimed to facilitate routine line service and major overhaul, but also to expedite non-scheduled repairs — a most important factor in airline operating economy.

Numerous doors and panels afford quick and easy access to prime maintenance locations in the craft. For example, under-floor section of the fuselage directly beneath passenger cabin is divided into various compartments illuminated by built-in floodlights and conveniently reached from ground standing position through access doors in the belly skin. When doors are open, warning light shows in cockpit. Equipment in each compartment has been grouped according to class, so that maintenance on a particular system can be advantageously accomplished in that specific location.

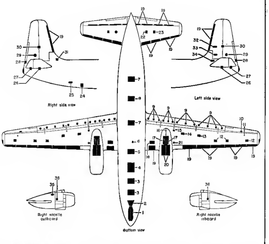
Inside facing of access doors is waffle-beaded sheet, spotwelded to outer skin. This construction affords increased strength and rigidity and prevents "oil canning." Pivoted arms, normally clamped in place on inner skin, can be swung up for attachment to hatch frame, thus securing door in open position. Flush spring latches (Hartwell) on door provide instant opening or closing with finger pressure.

Main landing gear wheel well, also illuminated by floodlight mounted on aft wall, affords ample room for maintenance of nacelle equipment. Located in center of firewall, which forms wheel well's forward limit, is large stainless steel access panel. This unit, equipped with pins at upper edge to fit into holes in surrounding firewall frame, has four Camloc fasteners at bottom edge for quick locking or unfastening. Between frame and panel is a fireproof seal. And with firewall

panel removed, there is complete access to accessory section on rear of engine.

Nose wheel well also provides extensive working space for servicing various accessibly located installations, including hydraulic reservoir, accumulators (gages attached), and brake cylinders. From nose wheel well, access is also had to main electrical disconnects into pilot's compartment and to rear of instrument panel. Built-in floodlight is at top of wheel well.

Another notable example of simplifying mechanic's job is found in arrangement for servicing the battery installation. Battery, located in fuselage electrical hatch, is supported in metal carrier equipped with hinge arms. Handles on carrier provide means for swinging it out of hatch, to render battery accessible for servicing from ground. Tilting of carrier facilitates battery removal. To place



Shown here are various servicing and maintenance access provisions on Martin 202: (1) Nose wheel forward doors, (2) aft door, (3) heater hatch, (4) radio hatch, (5) electrical hatch, (6) power receptacle door, (7) fuselage hatch, (8) cargo hatch, (9) flap inspection doors, (10) aileron actuator rod cover, (11) access hole cover, (12) outer wing door, (13) outboard tank door, (14) inboard tank door, (15) rear spar splice gap cover, (16) main gear strut door, (17) nacelle access doors, (18) leading edge access door, (19) removable leading edge, (20) main gear doors, (21) front spar splice gap cover, (22) elevator tab torque tube connection door, (23) tab actuating gear box door, (24) lavatory hatch, (25) ramp mechanism door, (26) stabilizer panel, (27) stabilizer rear spar and elevator torque rod panel, (28) tab panel, (29) rudder spring tab rod door, (30) fin-to-rudder hinge plate, (31) heating duct connection door, (32) tab gear box door, (33) rudder tab torque tube connection door, and (34) fin front spar bolt door. Nacelle details: (35) Oil tank filler door and (36) fire extinguisher nozzle insertion door. Left nacelle (not shown) has similar details.

battery in connected position, carrier is first swung up on hinge arms; then carrier cover, pivoted in hatch compartment, is clamped down over carrier, effecting a fume-tight seal and simultaneously making electrical contact via metal receptacles which fit over battery terminal posts.

Water Injection Provision

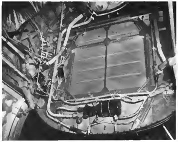
In top rear portion of each main wheel well is deep V-shaped structural member stressed to carry additional load of supply tank for power plant water injection. Tank is optional installation, which may be desired if craft is to be operated in localities which present adverse landing or takeoff conditions, or which involve high altitude flight.

Heating Installation

Two Stewart-Warner gasoline units located in aft portion of each engine nacelle discharge into a common chamber (mixing box) in fuselage section. This arrangement permits utilization of all heaters simultaneously, or, as an alternate, only those in either nacelle, to perform general heating functions and thermal anti-icing of wings, stabilizers, and fin. Leading edges of these airfoils are removable, they are lined with Fiberglas insulating material.

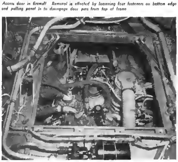
Under-Wing Fueling

In addition to provision for conventional (over-wing) fueling, under-wing filler valve affords fueling at rate of 200 gpm. or defueling at 100 gpm. Filler valve consists of housing,



Access door in firewall Removal is effected by loosening four fasteners on bottom edge and pulling panel in to disengage door pins from top of frame

Nacelle cutaway, depicting ease of mechanic's position for maintenance of accessories through firewall door



With firewall door removed there is complete access to equipment on rear of engine

safety cap, hose connection fitting spring loaded inlet piston, spring-and pressure operated outlet piston, and four flap-type check valves for defueling Outlet piston in filler valve is connected by flexible hose to needle valve in a float unit

In filling tank, small spring latch operated access door is opened in wing undersurface and safety cap on filler valve is removed Fuel hose nozzle is inserted in filler valve and handle on nozzle is pulled down, locking hose to valve As hose nozzle is inserted in valve, spring-loaded inlet piston is forced up to open position As fuel is pumped into valve, it holds defueling flap-type check valves closed, forcing outlet piston open, allowing fuel to flow out of outlets in filler valve housing Bleeder hole in outlet piston allows some fuel to flow up through piston shaft and through flexible hose to float unit So long as float is down, needle valve remains open and fuel will squirt through it As tank reaches full capacity, float rises and closes needle valve Fuel passing through bleeder hole in outlet piston no longer has an exit and builds up pressure behind outlet piston, forcing it down and closing outlet openings. When hose nozzle is disengaged from filler valve, spring-loaded inlet piston drops and closes inlet opening in valve Safety cap is replaced and access door closed.

In defueling, hose is connected as for fueling Since inlet piston is open and no incoming pressure keeps flap-type check valves closed, fuel drains from the tank

Fuel quantity indicator, readily visible, is housed in side of flap hinge fairing, facing filler connection

Cabin Details

Entire fuselage floor features high-strength, lightweight "honeycomb" construction. Honeycomb core — which may be fabricated of paper, cotton, cloth, Figerglas, or linen — is enclosed in aluminum alloy sheet, and the panel thus formed, approximately 1 in thick, is sealed at the ends with maple strips

Honeycomb construction is also used for bulkheads in cabin area.

To eliminate need for portable loading units, provision is made for front and rear integral ramps — contoured to fuselage exterior — operated hydraulically or manually from inside Exterior emergency control is also provided Safety features prevent inadvertent lowering of ramps in flight.

Front ramp is on fuselage side aft of pilot's compartment Rear ramp is on underside of aft fuselage section

and extends from rear of cabin to beneath leading edge of fin

Flap Installation

Wing flaps, attached to hinge fittings below trailing edge of wing, consist of two inboard and two outboard sections interconnected mechanically to slats (vanes) and to shutter doors that operate to maintain normal wing contour line with flaps in up position and close gaps between wing and flaps, thus assuring smooth airflow over wing

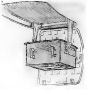
Flap hinge brackets extend below flap and are covered by streamlined fairings which match corresponding fairings covering the hinge brackets attached to wing

There are four slats — one each for inboard and outboard flap sections — hinged to trailing edge of upper surface of wing, and serving to increase maximum lift co-efficient by controlling airflow over flap when it is in the down position

Flap shutter doors are attached to trailing edge of lower surface of wing. There are three doors for each outboard wing flap and two for each inboard flap Shutter doors present an unbroken surface to flow of air across lower surface of wing with flap in up position As flaps are lowered, doors open to permit flow through slat. This increases effectiveness of flaps in down position by reducing turbulence and burble

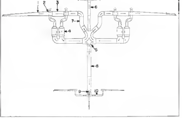
With shutter door open, entire trailing edge section is exposed for inspection of torque tubes, cables, etc

A fuselage flap, conforming to bottom of fuselage contour and extending across its entire width, forms a continuation section bridging the gap be

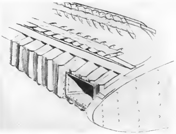


Seen here is battery in container swung down from hatch on hinge arms, accessible for servicing from ground standing position. Behind container is hatch access door, faced with waffle beaded sheet

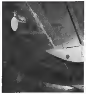
After battery container is positioned in hatch, cover is closed to effect fume-tight seal Integral receptacles seen on underside of cover provide electrical contacts for battery terminal posts



Schematic view of anti-icing system: (1) Wing leading edge, (2) air intake, (3) duct over main gear nacelle, (4) heater, (5) mixer box, (6) duct to windshield anti-icer, (7) to wing, (8) to empennage, (9) to fin, and (10) to stabilizer



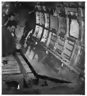
Seen in this sketch of stabilizer anti-icing details, removable leading edge (top) has corrugated inner skin (for heat passage) backed by Fiberglas insulation strips. Duct opening is in corrugated spanwise baffle



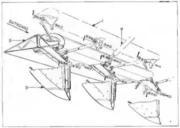
Open access door reveals safety cap for under-wing fuel filler valve. Fuel quantity indicator is seen housed in flap hinge fairing.

Rear integral ramp (incomplete) in extended position. Hydraulically or manually operated unit extends from aft of cabin.

Front ramp (mockup installation shown) is located just aft of pilot's compartment on fuselage left side.

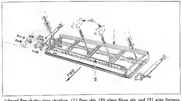


Metal-clad honeycomb fuselage floor panel is shown being installed on production line. End edges have maple strips.

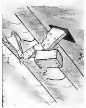


Inboard wing flap installation: (1) Vane, (2) flap (3) hinge fairing, and (4) screwjack.

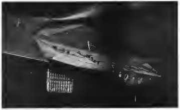
Bottom aspects of flap installation in extended position: (1) Flap (2) vane (3) wing trailing edge, (4) flap shutter door, and (5) fairing for hinge attached to wing structure, which matches fairing normally covering flap hinge shown exposed.



Inboard flap shutter door structure. (1) Door skin, (2) piano hinge pin, and (3) wing formers. Brush seals on ends of shutter door are used to seal gap between it and flap hinge fairing.



Even small details receive attention. When flap is retracted and shutter door closes gap, slat arm hole in door is sealed by rectangular fairing block for better streamlining. Shown are: (1) Flap (2) slat, and (3) shutter door.



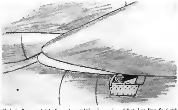
Shown here is fuselage flap in extended position, bridging gap between wing inboard flap sections. Construction embodies spars, ribs, and stiffeners.

tween inboard flaps on either side. This installation, in addition to giving more lift, increases efficiency of main flap by reducing end-losses.

Adjustable Stabilizer

Stabilizer is interconnected mechanically to flap torque tube system to counterbalance pitching moment change created when flaps are extended. Thus, angle of incidence of stabilizer automatically varies with flap deflection, trimming out the pitching moment. This obviates necessity of using elevators to trim out the positive pitching moment.

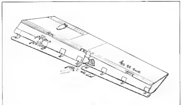
Stabilizer is hinged at front spar to bulkhead, and is actuated by rod connected to rear spar.



Mechanically connected to flap system, stabilizer is seen here deflected up from fixed stub section. Hinge point on front spar is also visible. Actuation connection is at rear spar. For flap deflection of 55 deg. stabilizer moves 6 deg.

Aileron Details

Aileron is van Zelm slot lip type. Balancing weights, distributed spanwise along the leading edge, balance aileron dynamically, and aileron vane balances the unit statically. Aileron is hinged at its junction with upper surface of wing to prevent gap in this surface when aileron is moved. Since vane is attached to leading edge of aileron lower surface, it will be in airstream when aileron is in up position, and it helps to direct smooth flow of air across lower surface. Increase in effectiveness of aileron at high angles of attack reduces possibility of stalling out because of turbulence, and thus allows use of comparatively smaller ailerons and permits correspondingly greater flap span. (See page 201, Dec 1944 AVIATION, for full discussion of this unit.)



Feature of van Zelm aileron, seen here, is auxiliary vane below leading edge, which functions to produce smooth flow over lower aileron surface in up position.

Tremendous power of 6000C4 is evidenced as all four cylinders of engine are fired in exacting 30-deg. angle test.

RMI'S ROCKET ENGINE Which Powers Supersonic XS-1

By JOHN SHESTA, *Director of Research & Engineering, Reaction Motors, Inc.*

Upward of 6,000 lb. total thrust is developed by Reaction Motors' liquid propellant regenerative rocket plant — which has already proved its mettle in initial flights of Bell's sonic-barrier-challenging XS-1. Using special injector, positive starts and stops may be made repeatedly. And being small, light for its power, and compact, engine features ease of installation.

SPECIFICALLY DESIGNED to propel piloted aircraft at velocities greater than the speed of sound, Reaction Motors' Model 6000C4 rocket engine was developed through close co operation of the company with the Services, and it is the first all-American attempt along these lines Representative of modern design, this engine is the end product of extensive research and experimentation under the direction and guidance of the founders of RMI—four pioneers in the field of rocketry in this nation Lovell Lawrence, Jr., is president, H Franklin Pierce is vice-president, James H Wyld is secretary, and chief research engineer, and the author of this article is treasurer, and director of research and engineering

First practical application of the power of the 6000C4 is in the Army's experimental supersonic airplane, the Bell XS-1, which has already been flown in successful initial tests at Muroc Army Air Base

The relatively small, highly powerful unit may be defined briefly as a liquid propellant regenerative rocket engine which develops almost instantaneous total thrust upward of 6,000 lb., or fractions of total thrust in increments of 1,500 lb To present a clearer conception of thrust, it may be stated that at 375 mph., thrust is numerically equal to horsepower In contrast to the high output of the engine are its relatively low weight and small size Its total weight is 210 lb, and it occupies a space of approximately 19 in. dia by 56 in. long, providing a compact installation in the XS 1.

In addition to compactness, it features ease of installation in aircraft, requiring but a matter of a few minutes The only connections that need be made consist of attaching the engine to the airframe at four mounting points, fitting the two propellant feed lines to the manifold inlets on the engine, and connecting the electric lead wires into a standard socket on the engine control box.

Basically, the engine consists of four combustion cylinders plus all the necessary piping, wiring, and controls, supported by a single main beam assembly. With minor exceptions, such as piping, wiring, and the control box, the entire unit is constructed of high grade stainless steel Major components of the engine are almost entirely of welded construction.

Fig 1 shows the schematic construction of a typical combustion cylinder The engine operates from the controlled combustion of a fuel and an oxidizer, An alcohol-water mixture is the fuel, and liquid oxygen is the oxidizer These

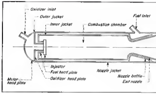


Fig 1 Schematic construction of typical combustion cylinder

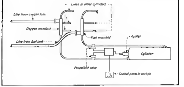


Fig 2. Schematic flow diagram of 6000C4 engine This illustrates system of propellant supply of one cylinder, other three cylinders are similarly served

propellants are injected under pressure into a combustion chamber, where they are thoroughly mixed and ignited. The rearward expulsion of the combustion products through the nozzle in the form of a jet of hot gas reacts as forward thrust.

From the appearance of the engine or from the above brief description one may get an impression that development of the Model 6000C4 rocket engine was a simple task. In general, a rocket engine is actually a simple power plant. However, the 6000C4 is a design with rigid specifications for compactness, controllability, endurance, reliability, safety, etc The fuel and oxidizer are highly potent, and special precautions are mandatory in their handling A considerable amount of RMI time and effort on experimentation and research, complementing the experience and knowledge of the original four founders, was responsible for the final product. Especially intricate were the engineering problems involved in controlling the vast power in so small a space.

Major components of the engine are: Main support beam, control box, propellant manifolds (fuel and oxygen), propellant valves (of which there are two types—fuel and oxygen), igniters, and combustion cylinders (see Fig 2) The main beam assembly, as its name implies, is provided to support all the other components as a single unit

All phases of the operation of the complete power plant are actually regulated by a "master-mind" control box. The fuel and oxidizer enter the propellant manifolds from their pressurized tanks Their pressure regulated by the propellant valves, the propellants flow to the combustion cylinder, where they are mixed in the injector and sprayed into the combustion chamber The igniter, itself a miniature rocket engine, sets off the mixture, and the resulting mass of hot gases roars out through the exhaust nozzle at tremendous velocities—in the neighborhood of 6,500 ft. per second. Theoretically, in the exceedingly thin upper atmosphere an aircraft could be propelled at the speed of the jet

The combustion in the rocket engine takes place in the combustion chamber at a very high pressure, and because of this, as well as because of the energetic nature of the propellants used, a rocket engine develops intense heat (4,500-5,000 deg. F) on the combustion cylinder walls To offset this the combustion cylinders of the 6000C4 are so designed that the liquid fuel, before entering the combustion chamber, passes between the inner and outer cylinders (see Fig 1) The fuel cools the walls and in turn the heat from the walls tends to evaporate the fuel before it is injected into the combustion chamber

This principle is known as regenerative cooling, because the heat absorbed by the fuel is returned to the combustion chamber This method of cooling is so effective that the stainless steel nozzle and combustion wall do not suffer any erosion or overheating, even after several hours of operation. The external temperature of the cylinders rarely exceeds 140 deg F

Since alcohol and liquid oxygen do not ignite spontaneously, an igniter has

Details of complete unit are brought out in this left side view of Reaction Motors' 6000C4 liquid propellant regenerative rocket engine been developed to initiate the combustion. This unit is a very small rocket engine attached to the head of each combustion cylinder. It is fed the same propellants as the main combustion chamber. Started with a sparkplug, it may be turned on or off at will.

One of the requirements in designing this engine was that it should be capable of repeated starts and stops in various attitudes, including firing with the nozzles pointing 30 deg. upward. In order to comply with these requirements, a special injector had to be developed. This difficulty overcome, the engine can now be started easily in any position. In fact, positive ignition has been obtained even when, previous to starting, the combustion chambers of all the cylinders were tilted up and filled with water.

Many other functional problems had to be worked out. Control valves and other accessories had to be designed especially for the engine. Production methods were used wherever possible, so that when the prototype proved satisfactory, additional units could be manufactured as required.

It is a curious fact that in the field of rockets the speed of developments appears to be simulating the speed of the rockets themselves. Despite numerous improvements since the 6000C4 was first manufactured, we are considering it as but one phase in the development of rocketry. To one who has been closely associated with the engineering of the 6000C4, it gives great satisfaction to know that the engine is being employed to power the first man-carrying supersonic aircraft in this country.

Engine test with three cylinders firing. Note that Mach waves are visible in jet stream. Of interest is fact that Germans gaged jet velocities by method involving measurement of jet temperature using spectrographic means and chemical analyses of the jet gases. Knowing velocity of propagation of compression wave, they determined jet speed from angle of reflected waves.

Powerful 6000C4 power plant was developed through painstaking research and experimentation directed by the four rocket pioneers who founded RMI—Lovell Lawrence, Jr., president (left); H. Franklin Pierce, vice-president (center); James H. Wyld, secretary and chief research engineer (right); and the author of this article, John Shesta, treasurer and director of research and engineering (photo below).

Author John Shesta, research-engineering head, is seen here calibrating a reaction balance.

FACTS ABOUT ROCKETS*

The rocket-propelled missile shows a superiority over other types both at very short and very long ranges.

A rocket traveling outside the earth's atmosphere, where air resistance is zero, can reach a speed at which centrifugal forces balance the pull of gravity. In this case the range becomes infinite without any further expenditure of energy or mass by the rocket.

Atomic energy can also be considered as a possibility in rocket propulsion, but any advantages are limited by the fact that a rocket must carry along the mass needed for propulsion, as well as the energy.

To attack a target 500 mi. distant, an initial velocity of 22,200 ft. per sec. is required. Assuming a jet gas velocity of 7,000 ft. per sec., a four-stage rocket is needed, having a take-off to payload weight ratio of 250:1 and the structural weight of that stage. On such a hypothetical flight no energy is lost except a small amount at the beginning, since the trajectory lies almost wholly outside the earth's atmosphere.

A rocket can travel much faster than its own jet velocity.

It is possible to build a rocket having a ratio of full-to-empty weight exceeding 27:1, even if it must carry a heavy load.

*Excerpts from article, "Rocket Propulsion," by R. W. Porter, Aeronautic & Marine Engineering Divisions, General Electric Co.; *The Coast Artillery Journal*, Oct., 1946.

. . . TOWARD BETTER COCKPITS
An Engineering Approach

By **STANLEY A. HALL**, *Northrop Aircraft, Inc*

First discussing too-often-neglected elements affecting cockpit design, Engineer Hall then outlines a novel "formula"—a current Northrop development—to evaluate which controls are most used and what locations are most accessible.

A GREAT DEAL HAS BEEN WRITTEN about the urgent need for more effective design of airplane cockpits. And though it is clearly recognized that controversies on this subject exist between designer and pilot, progress in converting meritorious ideas into practical cockpit designs has been painfully slow.

The integrated system of airplane design currently employed by the larger manufacturers is partially responsible for the existence of cockpit control arrangements that fall short of assuring optimum safety and efficiency. It is understandable that where many groups are concerned with getting controls and equipment into the cockpit, there exists numerous interpretations of the fundamental precepts of the airplane. And for each interpretation, there is a separate design philosophy—result: A cockpit that is not wholly suited to the pilot, who must put the whole layout to work on an overall, functional basis.

Through no fault of his own, the individual designer bears the brunt of

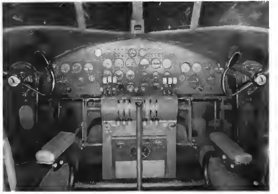


TABLE I — BREAKDOWN OF NORMAL AND EMERGENCY PROCEDURES

Airplane Type — Twin-Jet Fighter
Basic Airplane Function. High Altitude Combat — Importance Factor (F_1) = .70

	Normal Airplane Procedure	Normal Procedure Importance (F_{P_n})
A	Takeoff	20
B	Climb to altitude	10
C	Cruise	05
D	Engage in combat	40
E	Letdown	05
F	Land	20
	Total	1 00

Emergency Procedures — Importance Factor (F_1) = 30

	Emergency Condition	Condition Importance (F_{P_e})
A	Failure of one power unit	10
B	Failure of both power units	20
C	Fire	25
D	Landing gear failure	30
E	Failure of drop tank mechanism	15
	Total	1 00

responsibility for the lack of acceptable design progress Not being a pilot, he can only be guided by miscellaneous opinions of the pilot Getting both to work together, it would appear, would assure mutual satisfaction But here are encountered two basic difficulties First, neither pilot nor designer has the training or experience to understand the other's problems. Hence, what overall improvement might result, is sure to be marginal—insufficient to offer a solution to the problem Second obstacle is found with the pilot himself. Great majority of these men are eager to cooperate in setting up new designs Experience has shown, however, that their opinions are difficult to refirst, because of inconsistency. Any number of pilots will have different opinions about how this-and that should be arranged in the cockpit. Notoriously representative of this characteristic are designs of instrument panels—there being probably as many "optimum" layouts as there are people who design them and pilots who look at them

Also, it is felt by some that technological advance is so rapid that, by the time a plane is built, the design is already obsolete; hence, it may be an undue hinderance to base a new design on opinions of a pilot who flies an obsolete craft.

A few of the more important—and almost universally neglected—elements which affect cockpit design, are:

1. *Engine Starting and Stopping Procedure* Starting and stopping a large engine is a complicated process, usually requiring simultaneous use of both hands. At same time, pilot must observe certain engine instruments Investigation will indicate desirability of arranging controls to preclude necessity of having both hands at same side of the cockpit simultaneously, or of having to cover considerable distance in moving from one control to another.

2. *Trimming Airplane Under Various Conditions* Trimming is important in many phases of flying and probably is used more than any other secondary control It is particularly important when operating flaps or landing gear and in instrument flight Placement of the trim control should be based, as is location of other controls, upon its numerical importance as determined from analysis

3 *High Altitude Procedures* A plane intended solely for high altitude work should have all controls and instruments used at altitude placed with a high priority over others, whereas the cockpit of a craft intended for occasional high flight may be designed with possibly less emphasis on arrangement of high altitude controls.

It should be remembered that oxygen is imperative above 10,000 ft. In night operation, military services require oxygen from the ground up, for a minute lack of oxygen can reduce pilot's night vision as much as 50%.

An oxygen regulator or valve cannot be reliably operated by feel It must be seen Consequently, adequate lighting must be afforded

4 *Radio Procedures.* In long distance flying—particularly instrument flying—radio is indispensable. Radio controls should be allowed a high degree of consideration on "weight", since they are so vital to flight and avigation One of the most important radio controls is the volume control, and during instrument approach, pilot should be able to locate this control readily.

5 *Emergency Procedures.* Under this heading come such causative factors as Fire, malfunctioning of landing gear mechanism, engine failure, necessity for ditching, emergency landing and takeoff, and necessity for bailing out

Possibilities involved in the occurrence of these emergencies should be analyzed, and time required to execute the pertinent procedure should form the basis of design considerations

6 *Division of Work Between Pilot and Co-Pilot* On some airlines, instrument procedures are accomplished by co-pilot, under the direction of pilot, who concerns himself mainly with the radio Full study of other phases of this work-division should be made if optimum cockpit arrangement is to be attained

7. *Instrument and Night Flying* Obviously, instrument or cockpit arrangement suitable for contact flying will not necessarily be suitable for instrument flying Optimum in arrangement would be predicated upon anticipated amount of contact flying versus that of instrument flying.

Some degree of variation exists between day and night flying as that between contact and instrument flying Cockpit lighting for night flying is usually a troublesome factor, in that even a very small amount of light may momentarily reduce pilot's vision beyond cockpit confines Windshield glare caused by cockpit lights must also be investigated, as well as use of electrical switches with phosphorescent handles, because of possible windshield reflection And it must be remembered that some controls may not be visible at night, thus requiring additional identification.

8 *Effects of Acceleration On Control Usage.* Effects of high acceleration on pilot's ability to operate certain controls are very pronounced It is entirely conceivable that in a high-G pull out, pilot would find the weight of his arms forcing the control column back farther than intended, his ability to control acceleration being greatly reduced. Emergency controls placed high in the cockpit might be impossible to reach under these conditions.

Where the design requires a prone position for pilot, effect of acceleration on his ability to control the plane may be much greater than for an upright position, since, while prone, the shoulder cannot be used to help move the arm against acceleration This should require that all primary and emergency controls be operative with minimum pilot movement, also that necessity for moving against acceleration be held to a minimum.

9. *Understandability of Instruction Plates* Wording of instruction plates is probably the most important element of cockpit features. These units usually have a primary defect in that they do not sufficiently consider one very basic requirement—that pilot does not have time for sufficient concentration in the air, as he has on the ground. Unless pilot is well accustomed to his plane, circumstances may occur in which there isn't enough time to digest contents of an instruction plate. Also, many pilots fail to remember the many emergency procedures they may be called upon to perform. If plates for emergency controls have long and complicated instructions, and circumstances are "right", pilot may be tempted to use his final alternative—that is, to bail out.

10 *Crash Hazards* Cockpits should be designed to offer maximum crash protection. Brackets, equipment, control levers, handles, etc., should never be located where pilot may strike them should he be forced forward or sideways in his seat. It is not uncommon for a tricycle-geared plane to land with a small amount of drift, tending to thrust pilot to one side of cockpit. Sharp corners, and projections can cause injury in such case.

The numerous available publications on crash protection should prove of great value to the cockpit designer.

Consideration of the foregoing items, together with the more obvious cockpit functions, leads to the realization that pilot opinion must give way to something more definite. To this end, Northrop Aircraft Co. has under current development a system whereby a cockpit may be designed to a "formula".

Basic philosophy of the formula is expressed by Dr. E. F. Du Bois, of National Research Council on Aviation Medicine, who analogizes cockpit control elements to an extension of pilot's nervous system. A control arrangement designed after pilot's habit-pattern would be sure to provide high efficiency. True, a pilot can, by proper training, learn to control his conscious habit-patterns to an advanced degree However, in circumstances requiring quick unplanned action, the subconscious arises to meet the occasion. It would be highly desirable to arrange controls so that difference between pilot performance under control of conscious habit-patterns and that under control of subconscious action would not be too far apart.

To accomplish this it is necessary to make the cockpit simple, for both pilot's conscious and subconscious self can comprehend simple things Thus, it is necessary to place controls most used in the most accessible places. Determination of just what controls are "most used" and just what areas are "most accessible" are the two unknowns which the formula evaluates.

Derivation of formula for determining relative use of controls is based upon investigation of the various procedures pilot must perform, so that the basic design-intent of the particular airplane be realized.

First step is assignment of "factors of importance" with the realization that pilot has two basic jobs—first, to control all normal functions of the airplane; and second, failing in this, to cope with any emergency that may consequently arise.

This means that the sum of design effort involved must be divided between normal and emergency pilot procedures in the ratio of their importance to the whole Based on a "total importance" to the airplane of 1 00, controls designed for normal use might command a relative importance of, say, 80, and emergency controls 20 If the airplane were of radical design, where emergency procedures might conceivably be of greater use, the "importance factors" might be considerably altered. These importance factors should be assigned by personnel familiar with the plane's intended function, piloting technique, and procedure employed

Normal and emergency procedures are to be further broken down—as illustrated in Table I, which considers a typical, twin-jet, high-altitude fighter.

Adjacent to the column headed "Normal Airplane Procedure" is col-

TABLE II — CONTROLS USED IN NORMAL AIRPLANE PROCEDURES

	Control	Procedures in which Required (from Table I)
1	Throttles	A, B, C, D, E F
2	Landing gear, normal	A, F
3	Elev trim	A B C D, E F
4	Rudder trim	A B, C D, E F
5	Flaps	B, E F
6	Gun switches	D
7	Gun charging handles	D
8	Fuel valves	B, C F
9	Oxygen	B, C, E
10.	Radio	A, B, C, D E F

TABLE III — CONTROLS USED UNDER EMERGENCY CONDITIONS

	Control	Conditions under which Used
1	Fuel valves one or both	A B C
2	Ignition switches, one or both	A B, C
3	Master switch	B C
4	Fire extinguisher switch	C
5	Cockpit enclosure, emergency	B, C, D
6	Emergency landing gear	B, D
7	Emergency drop tanks	B, C, D, E
8	Rudder trim	A, E

TABLE VI — WEIGHTED CONTROL USAGE FOR NORMAL PROCEDURES = $F_{P_n} \times \frac{F_{P_x}}{1}$

Procedure	F_{P_n}	Control No. (From Table II) 1	2	3	4	5	6	7	8	9	10
A	20	080	040	050	020						010
B	10	040		025	005	020			005		005
C	05	018		012	004				005	005	005
D	40	200		040	040		040	040			040
E	05	015		010	005	010				005	005
F	20	060	060	020	010	040			010		010
		413	000	157	065	070	040	040	020	010	075
		Total = 1 006									

TABLE IV — RATIO OF INDIVIDUAL CONTROL IMPORTANCE TO TOTAL PROCEDURE $\left(\frac{F_{P_n}}{1}\right)$

Procedure	Normal Control No. (From Table II) 1	2	3	4	5	6	7	8	9	10	Total
A	40	20	25	10						05	1 00
B	40		25	05	20			05		05	1 00
C	35		25	10				10	10	10	1 00
D	50		10	05		10	15			10	1 00
E	30		20	10	20				10	10	1 00
F	30	25	10	05	20			05		05	1 00

TABLE V — RATIO OF INDIVIDUAL CONTROL IMPORTANCE TO TOTAL PROCEDURE $\left(\frac{F_{P_e}}{1}\right)$

Condition	Emergency Control No. (From Table III) 1	2	3	4	5	6	7	8	Total
A	30	30						40	1 00
B	10	10	10		20	30	20		1 00
C	30	10	10	20	30		10		1 00
D					30	40	30		1 00
E							30	20	1 00

TABLE VII—WEIGHTED CONTROL USAGE FOR EMERGENCY PROCEDURES $= F_{p_e} \times \frac{F_{c_e}}{1}$

Condition	F_{p_e}	Control No. (From Table III) 1	2	3	4	5	6	7	8
A	.10	.030	.030						.048
B	.20	.020	.020	.020		.040	.060	.040	
C	.25	.050	.025	.025	.050	.075		.025	
D	.30					.090	.120	.050	
E	.15							.120	.030
		.100	.075	.045	.050	.205	.180	.275	.070
						Total = 1.00			

TABLE VIII—WEIGHTED CONTROL IMPORTANCE FOR DESIGN CONDITIONS

Normal $= F_1 \left(F_{p_n} \times \frac{F_{c_n}}{1}\right)$ $F_1 = 70$

Control	$F_{p_n} \times \frac{F_{c_n}}{1}$	$70\left(F_{p_n} \times \frac{F_{c_n}}{1}\right)$
Throttles	.413	.290
Landing gear normal	.090	.063
Elevator trim	.157	.110
Rudder trim	.065	.046 (.067)
Flaps	.070	.049
Gun switches	.040	.028
Gun charging handles	.060	.042
Fuel valves	.020	.014 (.044)
Oxygen	.010	.007
Radio	.075	.053

Emergency $= F_2 \left(F_{p_e} \times \frac{F_{c_e}}{1}\right)$ $F_2 = 30$

Control	$F_{p_e} \times \frac{F_{c_e}}{1}$	$30\left(F_{p_e} \times \frac{F_{c_e}}{1}\right)$
Fuel valves	.100	.030 (additive)
Ignition and starting switches	.075	.022
Master switch	.045	.013
Fire extinguisher switches	.050	.015
Emergency cockpit enclosure	.205	.061
Landing gear emergency	.180	.054
Emergency drop tanks	.275	.082
Rudder trim	.070	.021 (additive)

umn for "Normal Procedure Importance". Importance factors are assigned to each of these procedures just as was done in assigning factors to the basic procedures. Here, it is assumed that the tactical mission of the plane is the most vital of the normal procedures, hence, a value of .40 is assigned. Remaining procedures are similarly evaluated. Overall total is 1.00. At the present stage of formula development, these importance factors are somewhat arbitrary, and it may be possible with further development and experience to assign more accurate values.

Same procedure is employed in evaluation of emergency procedures (see bottom of Table I).

Table II enumerates all controls used to accomplish the normal procedures, while Table III designates those for the emergency procedures.

Next step is to evaluate relative importance of each control to the others, for each procedure. This has been done in Table IV for normal procedures and in Table V for emergency procedures.

Subsequent step is to multiply values in Table IV by corresponding importance factors in Table I, listed under "Normal Procedure Importance". Same is done for the emergency procedures (Table V), using "Condition Importance" factors shown at bottom of Table I. By adding each resulting vertical column, a weighted average is obtained. As an additional check, these sums should together add up to 1.00. These procedures are illustrated in Tables VI and VII.

Result, up to this point, is a representation of relative importance of each control in accomplishing normal procedures and the same for accomplishing emergency procedures. Numerical relation between normal and emergency procedures is determined by multiplying each of the vertical columns in Tables VI and VII by the proper "Basic" or "Emergency Importance" factor. In the case of the "Basic Airplane Function," the factor 70 is used for the normal procedures; for emergency procedures the factor 30 is used as a multiplier. This procedure is shown in Table VIII.

Relative importance of all controls, for all procedures, normal and emergency, is determined in Table IX by merely arriving at a numerical order of controls, the largest value becoming number 1; second largest, number 2; etc. Where a control is used in both normal and emergency procedures, the sum of the numbers for this control is employed. Prior to this, however, there must be a determination of which controls shall, or can, be operated by left or right hand. Determination of the proper division of work between the hands is based upon percent of total time the left or right hand can be conveniently spared from the control stick or wheel to operate other controls. This is determined for each of the normal procedures. It is assumed that use of emergency controls by left or right hand will be dictated largely by nature of the emergency, consequently only the normal procedures are used as a basis for determining the proper division of work.

Evaluation of division of work is obtained by multiplying the percent of work for each hand, for each procedure, by the importance factor, F_{pn}, of each procedure. Summation of values for each hand yields the proper division of total work between the left and right hand. Controls are then placed for left- or right hand operation as required to cause the sum of importance factors for each hand to correspond to the values of proper work division previously determined. This procedure is shown in Table X.

This completes the determination of which controls are "most used". Next step is to determine where to place them. This is accomplished by dividing the cockpit into a number of "zones" and establishing, for each, a value of accessibility.

Areas on the sides of the cockpit, conveniently accessible to pilot, are shown in the illustration accompanying this article. The representation applies to a specific type plane, and would necessarily be altered to suit other types.

From pivot point of pilot's shoulder,

TABLE IX—CONTROL PLACEMENT IN TERMS OF NUMERICAL (ZONE) IMPORTANCE

Zone	Left Hand Control	Importance	Right Hand Control	Importance
1	Throttles	240	Radio	053
2	Elevator trim	110	Fuel valves	044
3	Emergency drop tanks	082	Gun switches	028
4	Rudder trim	067	Fire extinguisher switches	015
5	Landing gear normal	063	Master switch	013
6	Emergency cockpit enclosure	061	Oxygen	007
7	Landing gear emergency	054		
8	Flaps	049		160
9	Gun charging handles	042		
10	Ignition & starting switches	022		
		840		

a basic arc is drawn with a radius equal to horizontal distance from seat reference point to position specified by the AAF for location of throttle. Arcs of suitable radii are then constructed on either side of this basic arc.

Next, spaces between arcs are divided into a number of segments, the width of each segment representing that amount required for the installation of a control of average size and configuration. The segments are staggered to minimize possibility of pilot striking one control with his arm while operating another with his hand. Each segment is numbered according to accessibility, segment (1) being most accessible, segment (2) next most accessible, etc. These numbers should be assigned with consideration to various elements. For example, center arc preserves the angle a between pilot's upper arm and forearm. This means that controls placed anywhere along this arc could be operated with the same maximum efficiency. Arcs forward and aft of the center would reflect less efficiency of pilot operation. Since controls located low in cockpit are more difficult to see than those located higher, the lower segments are considered less accessible. As further development along these lines is realized, more accuracy in assigning values of segment-accessibility will result—for more efficient arrangement.

TABLE X—REQUIRED DIVISION OF WORK BETWEEN LEFT AND RIGHT HANDS

Normal Procedure	F_{p_n}	L. H.	$F_{p_n} \times$ L. H.	R. H.	$F_{p_n} \times$ R. H.
A	.20	1.00	.200	0.00	.000
B	.10	.50	.050	.50	.050
C	.05	.50	.025	.50	.025
D	.40	.80	.320	.20	.080
E	.05	.50	.025	.50	.025
F	.20	1.00	.200	.00	.000
			.820 L. H. Work		.180 R. H. Work

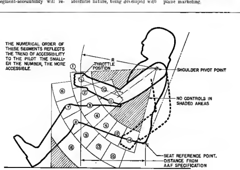
Departure of work division from theoretically ideal = .840 − .820 = .020
= .180 − .160 = .020

Segmental importance will also be based on the type or configuration of the control. Thus, some controls are easier to operate as twist-knobs, wheels, or push-pull controls, rather than as levers. Just which should be twist-knobs or wheels, etc., is rather difficult to determine, but choice should, perhaps be based on operating loads, sensitivity of control, mechanical advantage, and other factors. Development along these lines is going forward.

Final process in locating controls by this method is to place each control in accordance with the illustrated zoning trend.

It is recognized that the system here outlined is deliberately of an idealistic nature, being developed with little regard to the technical problems sure to arise. Though technical problems may dictate deviation, it should be first determined which can be more economically sacrificed—airplane operational efficiency, which is directly related to pilot convenience, or technical effort and expenditure.

It is worth considerable note, on the part of those who are responsible for marketing functions, that an airplane is "sold" through its cockpit. Basic impressions are acquired there. Regardless of structural and aerodynamic characteristics of the craft, if the pilot will not "buy" the cockpit he may not buy the plane, either. Cockpit design—through analytical means—will go a long way in facilitating that basically important problem of airplane marketing.

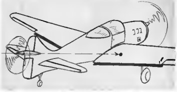


ACCESSIBILITY ZONING OF TYPICAL FIGHTER TYPE AIRPLANE

Rotative Flight Brake Proposed To Moderate Landing Speeds

By **JAMES G. RAY,** *Vice President, Southwest Airways Co.*

With AVIATION staff sketches by E. J. Balban



In actual use, states Mr. Ray, pilot sets wing flaps in full-lift position, switches on autorotating flight brake, and brings craft in at steeper angle than would be possible with drag flaps alone.

Submitted here is a method developed by the author for rapidly varying airplane drag — without disturbing the aerodynamic qualities necessary for optimum control at lesser velocities such as employed during alighting.

Continuous design refinement has resulted in aerodynamic cleanliness to the extent that acceleration buildup has necessitated lengthier approaches in order to keep final speeds to a minimum. This factor—causing a reduction in aircraft utility—has resulted in an intensive search for means of varying drag.

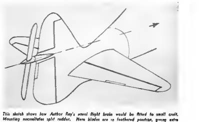
Flaps, split rudders, and rotating strut fairings to increase drag have all been tried, with the first named being the most generally used. However, the drag flap has a number of shortcomings. Probably the most outstanding of these deficiencies is that when the flap is used thus, it cannot also be employed for increasing overall lift—of great importance because of the necessity of keeping landing speed as low as possible. Other flap faults are that it must be large to be effective, thus appreciably increasing structural weight; moreover, it affects longitudinal stability, interfering with maneuverability.

It is well known that an autorotating rotor, pulled through the air with disk at right angles to direction of motion is the most practicable means of producing aerodynamic drag. Theoretically, the drag of a rotor is 1.6 times that of a flat plate having an area equal to the rotor's disk. In actual tests a figure of 1.5 has been obtained. Let's consider, therefore, the feasibility of using this high rotor drag as a means of decelerating aircraft.

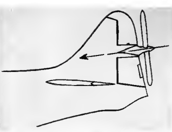
Probably the best place to install a drag rotor would be at the craft's tail, with the axis of rotation aimed through the plane's C.G., so that there will be no tendency for rotor forces to disturb the aerodynamic balance. In addition, full-lift flaps would be installed.

Such a rotor can be surprisingly small. On a 3,000-lb craft, diameter could be slightly less than 4 ft. and chord about 3 in., yet 250 lb. of drag would be produced at 75-mph. gliding speed. This drag would probably equal the normal drag of the airplane at this speed and would steepen the glide angle from about 12:1 (which can be expected for a well-designed aircraft) to approximately 6:1 when full rotor drag is applied.

It is believed that a rotor of this size can be built to weigh about 6-7 lb., and can be installed at an overall increase in weight of not more than 10-12 lb. When the rotor is inoperative, the blades could be feathered and aligned vertically with the rudder, thus providing extra vertical fin area. The rotor would not be mounted to the rudder itself because a movement of this surface would also move the rotor, thus producing a control action that would oppose that produced by the rudder.



This sketch shows how Author Ray's novel flight brake would be fitted to small craft. Mounting necessitates split rudder. Here blades are in feathered position, giving extra vertical fin area. Arrow aims through CG.



Some extra rudder area might be necessary to offset any disturbance in airflow passing through rotor. It's stated that such an installation fitted to small plane would weigh about 10-12 lb.

The greatest advantage of this type of flight brake would be in its ability to quickly vary the amount of drag. The rotor would be brought into operation by the pilot moving a lever, somewhat like a conventional throttle, to unfeather the blades and start them spinning. As blade angle was increased, speed of the rotor would mount, and when flat or autorotative angles are reached, rotor drag would develop until the optimum angle is attained, at which point the blades would go against a stop to prevent their being over pitched. Thus any amount of drag, from optimum to none, could be attained.

Such a control is badly needed in flying. It would be difficult to fully estimate all its values. A rotor flight-brake would provide pilots with a much larger variation of their glide paths than can be obtained in any other manner, and in a form that could be used easily, accurately, and safely. When landing in a small area, the pilot would set his flaps for maximum lift and his rotor brake for approximately half drag, permitting a relatively steep ascent, and making it easier to approach accurately. Then as he approaches, he can continuously adjust his glide path to remain lined up exactly on the spot on which he wishes to make contact. If he finds he is headed for an overshoot, he can adjust the rotor for more drag and steepen his landing.

These adjustments would make it possible to land accurately in small areas, and of course could always be counted on, even in event of engine failure.

Two other methods of decelerating aircraft have been devised. One means is to open a small parachute attached to the airplane's tail. This produces sufficient drag to give a steep glide path, but it incorporates no way of varying drag. If it becomes necessary to cut the chute loose because the plane is undershooting, then the landing must be completed without its assistance.

Reversing prop pitch is the other method of slowing aircraft. It can be used satisfactorily after a landing in order to shorten ground roll. However, use of the reversing prop during the glide is not promising, for two reasons: Turbulence tends to buffet the control surfaces, and in case power is suddenly needed in an emergency it will not become available until the airscrews can be reset for forward thrust.

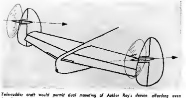
Actually the amount of drag (reversed thrust) that can be obtained from a reversed pitch prop is not as much as might be expected. When pitch is reversed, the propeller blade is running with its airfoil upside down, with twist opposite to normal. As a general rule, an autorotating rotor of equal diameter will produce more drag at glide speeds above 40 mph. than a power-driven reversed airscrew.

As far as the writer knows, the autorotative flight brake has not been tested in full-scale flight. Ground tests up to 80 mph. have been conducted by the author with rotors mounted on automobiles, without encountering unexpected difficulties. However, flight tests might reveal additional problems.

One of these would encompass the excessive speeds attained by blade tips when full drag would be applied to a craft traveling at high forward speed. It is believed that when blade tips reach the speed of sound, their rotational speed will be limited by the sudden increase in their drag. If this is found to be the case, hub and blades could be designed to carry the centrifugal forces generated at this speed. However, if this does not prove to be the upper limit to the rotor's speed, it might be desirable to install a governor that would limit rpm. to some selected maximum.

Another possible difficulty might be that rudder action would be affected by operation of the rotor behind it. This disturbance should be rather small, however, because airflow through the rotor is not slowed to any appreciable extent, and size of the rudder could be increased slightly in compensation.

Yet none of these anticipated problems seems to be serious enough to interfere with the intended use of rotary flight brakes.



Twin-rudder craft would permit dual mounting of Author Ray's device affording even broader control. Rotors would be so mounted that they would not be wiped off even during tail-low landing with tricycle gear craft.

AVIATION ABROAD

ENGLAND—Air Ministry officials have announced addition of six new types to official "Brabazon" list including 12-jet 130-ton flying boat, 60/70 ton jet landplane, 2 feederplanes, and 2 helicopters. They also stated that British will only have converted military craft available in quantity for next few years, and that to keep up with competition U. S. planes will have to be purchased. They estimated that only by mid-1950 will majority of military conversions have been replaced by new types. By that time they stated European fares will be down to an average of 4½c. per mile, and international fares to 6c.

In the meantime, BOAC, after receiving its first Tudor, announced cancellation of orders for 78 of these craft. Reasons given included pressurization troubles, bad performance in test flights and excessive empty weight. Instead, Hermes III and IV planes will be ordered, both of which are jet types. Unsuitability of Tudor and also of Hermes I was predicted previously (see Worldata, Oct. 1946 AVIATION), so BOAC's action does not come as a surprise. Insiders expect additional orders for Constellations or DC-6s to enable British airlines to keep their heads above competitive waters.

DeHavilland has now received an additional order for 20 Doves from Argentina, which raises total number of Doves now on order to 255 valued at $4 million dollars and destined for 20 countries on 5 continents.

Plans are being completed for immediate construction of prototype 100-passenger jet flying wing. Range is projected at 3,500 mi in 7 hr time with 100 passengers, crew of 14, and 7 tons of mail and freight.

FRANCE—First French J-P airplane—Leduc 0-10—was carried aloft piggy-back by large transport for its first powered flight. Reports indicate plane performed satisfactorily and that production will be started immediately.

RUSSIA—Official announcements stated that beginning in 1948 four engine high speed transports will be operated on world's longest airline in one country, between Moscow and Vladivostok. Toward end of '47, prototype of twin-engined 30-passenger successor to Russian-built DC-3 will also be flying as well as a 12-passenger twin engined feederliner and a 4-6 passenger feederplane.

INDIA—Asian Air Associates headed by Rusi Mistri, is contemplating plans to build Chrislea Ace now being produced by a subsidiary in England as soon as demand grows. Presently there are only 100 licensed private pilots in India, and only 27 airports which can be used. However, substantial government subsidies to flying clubs, special bonuses for new licenses and opening of military airports are expected to increase the number of pilots rapidly.

AUSTRALIA—News of signing of air agreement by both Australia and New Zealand with America was received with satisfaction. British Pacific Airlines will eventually take over operations pooling traffic with Canadian airline. However, both companies will bear own expenses and maintain own ground equipment and staffs, thereby duplicating major part of costs.

Reports from Australia indicate that British manufacturers are basing their sales campaign on a point which is getting much attention. They are guaranteeing that the airliners which they will deliver will be suitable for immediate installation of jet units with minimum of cost or trouble as soon as these units are commercially practicable.

PERU—Peruvian International Airways, new company headed by Lt. Gen. Harold L. George, and founded by a group including C. M. Keys, has ordered several Douglas DC-6s for use on proposed service to U. S.

SAN JOSE—Rate war is now in progress between TACA, LACSA and TAN. All companies originally charged same fares, but recently LACSA and TAN have been charged with granting discounts running as high as 75%, to groups of passengers, causing the current fare battle.

CUBA—Control of Expreso Aereo Inter Americano, local airline serving Miami, is reported purchased by Transair, New York. Transair will assign at least four DC-3s to Expreso, and intends to exercise Expreso's option to purchase from PAA, control of Cubana, only other Cuban operator.

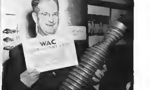
BRAZIL—This country is among first in Latin America to attempt to put an end to formation of air transport lines by irresponsible parties or promoters. New government regulations require $1 million capital for all new airlines which apply for a charter.

BRITISH TRANSONIC RESEARCH CRAFT

This expendable 6 ft span winged rocket to be used in gathering data for design of a full-size plane has bi-fuel German Walter type power plant and is expected to reach 800 mph. Loaded with telemetering devices and fitted with radar model will be dropped by Mosquito (as depicted in background) and fuel then ignited for flight of about 70 sec. When fuel is exhausted model will automatically dive into sea. ("The Aeroplane" British Combine photo)

DEALER SCHOOL TAKES WINGS

A new product-selling scheme inaugurated by Atlas Supply Co., Newark, N. J., utilizes a DC-4 (above) specially fitted out to house a complete line of company's aviation-auto goods in attractive display above. Craft is now touring more than 800 airports in U. S. and Canada featuring dealer promotion and training in the plane, and introducing new line of aircraft accessories. Equipped with 16 lounge chairs, bunk, and galley, flying showroom also has sound picture equipment in addition to neatly arranged displays.



POWER FOR THE WAC

First photo of small steel welded rocket engine which powers Caltech's WAC Corporal sounding rocket (page 119, May 1946 "Aviation") shows power plant's unusual configuration. Liquid fuel is spiraled around rocket's firing chamber as a coolant. Holding engine is W. L. Wilkinson, sales mgr. of Solar Aircraft, its maker. ("Aviation" photo)

Landing Gear Pre-Rotator Housed Within Wheel

Electric unit slated for test on Constitution employs "forgotten" winding. Low weight and compactness permit designing as integral part of wheel assembly.

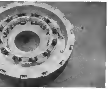
SCHEDULED FOR TRYOUT on Lockheed's new Constitution is an electric landing gear wheel pre-rotation unit developed by Otto E. Dever of Burbank, Cal. Of immediate commercial interest is a smaller unit he has developed for tests on Lockheed's "gold plate" Constellation.

The Constitution unit—of which 28 are reported under construction for Lockheed by Wells Aircraft Parts Co.—consists of an outer armature ring of 168 segments and a field unit of 12 coils. The motor uses a ring type winding, has a width of but 1¼ in., a dia. of only 10 in. across the air gap within the armature, and has a total weight of 15 lb. Both armature and coil are integral parts of the wheel assembly.

Preliminary engineering tests indicate that the motor will build up full pre-rotation of the Constitution's eight main landing gear wheels in 2 min., and hold it within 5% of touchdown speed, in this case 630 rpm. for a touch speed of 90 mph.

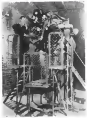
It is expected the Dever unit will be completely automatic in operation, with starting actuated by a switch set in operation by lowering of the flaps. In the Constitution an auxiliary power plant will provide an input of 120v., 50 amp., for a starting load equal to 9 hp., though peak rotation can be maintained with 15 amp. Lockheed specifications call for operation of the unit up to 5 min. per landing, with two such runs within 15 min., this latter to cover the possibility of going around for a second approach.

Landing gear wheel pre-rotation unit developed by Otto E. Dever, showing motor in foreground and commutator and armature in background. Unit uses ring type winding which can be varied to achieve necessary pre-rotation speeds of different aircraft.



Dever pre-rotation motor field unit and mounting in position for fitting on Hayes 15 x 4 brake. It is mounted on brake flange shoulder to assure concentricity. Insulation includes use of Dow-Corning 996 silicone varnish.

DC type Dever unit showing rotating element (armature) mounted on a 17.00-20 Hayes wheel employing dual 4-in. brakes.



Engine test cell is integral part of underground plant. By leaving natural rock walls between cells, only soundproofing necessary is on entrance doors and usual sound deadening between cells and control rooms. Exhaust vents, like ventilation system for other parts of plant, can be drilled up through hillside roof in zig-zag shape to eliminate bomb damage; lead seals in all outlets could be used to stop radioactivity of atomic bombs

Aircraft Engine Plant Goes Underground

First photos of Swedish factory show how proper use of color gives a feeling of roominess; indicate how low maintenance costs counteract initial high expenses.

Initial views of Bolinder-Munktell underground engine factory near Eskilstuna, Sweden designed and built to withstand even atomic bombing. Walls, ceilings and much of machinery are painted near-white to counteract claustrophobia. Lighting is mixture of fluorescent and incandescent to give warm shade akin to normal sunlight. Added "roominess" is achieved with light-structure partitions

Another aisle in Bolinder-Munktell plant, suggesting such rooms radiate from central point. Shown are overhead crane and air conditioning inlets. The even temperatures of underground plants have been found to reduce heating costs and, with proper air conditioning, greatly improve workers' health. In some cases fake windows backed by outdoor scenes are used to combat closed-in feeling. In this plant, air purifying equipment would permit workers to stay in as long as 34 hr. with all inlets sealed in event of atomic or poison gas attack. Conversely, emptying plant of workers and sealing outlets would be means of extinguishing fire within five to eight minutes

Machine tools can be arranged as efficiently underground as above surface, as shown here. Engineers see no practical limit to size for subterranean plants, and such installations can be made about as fast as conventional plants. This B-M plant was built and equipped in less than two years; another later one near Stockholm was set up in about half that time. Note doorways in side walls connecting to other workrooms which are probably of same size as this one

Photo during construction shows Tudor type arch achieved by careful blasting. Underground factory initial costs usually exceed those of conventional above-ground plants, but maintenance costs are much lower. Subterranean plant costs vary widely, depending on quality of rock, faults and cracks can add to expense just as they do in foundations for ordinary plant buildings

Static Stability Analysis For Flying Boats and Seaplanes

PART II

By ERNEST G. STOUT, Head of Naval Aircraft Research, Consolidated Vultee Aircraft Corp

Waterplane inertia and effect of free liquid surface on stability are discussed in this continuing presentation.

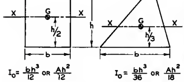


Fig. 4. Moment of inertia of plane figures about axis through C G

As we have noted in Eqs 22 and 23 of Part I (page 71, Dec '46, AVIATION). the expression for BM contains the moment of inertia of the waterplane area, in the numerator. Since this area depends upon the geometry of the hull in question and varies with each specific problem, it is desirable to review briefly the derivation of the moment of inertia of areas, and discuss accepted procedures available to the designer for calculating this value.

Moment of a force about a point is known to be the product of the force and perpendicular distance of its line of action from the point. Similarly, the moment of an area about a given axis is the area multiplied by distance of its C. G. from this axis. For an irregular area it is often convenient to divide the area into a number of small areas and to sum up the moments of all these small areas about the axis In all of these well-known cases, the force or area is simply multiplied by a distance. If, however, all of these small areas are multiplied by the distance squared, and the products added, the result would then be the moment of inertia of the area about the given axis

All engineering handbooks tabulate formulas for the moment of inertia of regular figures, several of which are repeated here. These moments of inertia are usually presented in two forms—first being when the axis is through the C.G. of the figure and parallel to the baseline, as illustrated in Fig 4 (known as the I_0 of the figure, such moment of inertia always being less than that about any other axis parallel to it), second, when the axis is one of the sides, as shown in Fig 5.

Referring to Fig. 6, it is desired to determine the moment of inertia of the irregular area $ABCD$ about base DC. Thus, take a strip PQ of length y and infinitely small width dx Then, taking PQ as a rectangle, we see that its moment of inertia about DC is,

$$\frac{1}{3}(y \times dx)\, y^2 = \frac{1}{3} y^3\, dx \tag{25}$$

where $y \times dx$ is the area Moment of inertia of the whole figure about DC will then be the sum of all such expressions as this, or,

$$I = \int \frac{1}{3} y^3\, dx \tag{26}$$

Since it is usually required to find the waterplane moment of inertia of a hull, about the centerline, we must add the moment of inertia of both sides and, because these sides are symmetrical, we have,

$$I = \frac{2}{3} \int y^3\, dx \tag{27}$$

where y is the semi ordinate of the waterplane We recognize this as the term that appeared in the numerator of Eq. 22

Because the infinitely small strip method is difficult to compute, and wishing to take advantage of the standard formulas given for regular figures in handbooks, it has been found that an approximate method, utilizing the standard formulas, is sufficiently accurate for seaplane analysis First step is to lay out waterplane halfbreadths from hull centerline, as shown in Fig 7 This is the half section of the hull cut by the plane of the normal free water surface when at rest The irregular area is then divided into a series of rectangles and triangles which closely approximate the irregular area Now, the moment of inertia of each regular area can be readily computed from the standard formulas, and the sum of all such moments of inertia very closely approximates the original waterplane.

Care should be exercised to use the appropriate formula—for not only the shape of the area in question, but also for its position Whenever a rectangle or triangle has a base that is common to the hull centerline—such as areas (1) and (4) of Fig 7, I is computed as shown in Fig 5 However, when the area is removed from the hull centerline, such as area (12) it is necessary to first compute its I_0 about an axis through its C G and parallel to the hull centerline, as shown in Fig 4, then multiplying this I_0 by the product of the area and the distance from area C G to hull centerline squared It should be remembered that the C G of a triangle is one-third the height from the base

If inch-dimensions are used, the units for moment of inertia will be inches to the fourth power This can then be reduced to feet to the fourth power by dividing by 12^4 or 20,740, as shown in Fig 7. (Since the semi-waterplane has been used, it is necessary to multiply by two to obtain total waterplane inertia) For most practical purposes, the preceding method for determining moment of inertia of waterplane area is sufficiently accurate and is recommended to the seaplane designer

In Part I we derived the expression for computing BM—distance from center of buoyancy to metacenter—and as explained, the metacenter is the predominate factor in all static stability calculations. If the seaplane consisted entirely of solid objects this value of BM would be sufficient. Unfortunately, however, the modern long range seaplane or flying boat contains a vast amount of liquid fuel, hence it is possible to have present a large destabilizing force, unless careful attention is paid to baffling this fuel into areas of small liquid surface. Because this factor is clearly out of proportion to what might be suspected by casual inspection it is deemed advisable to discuss this phenomenon, and its effect on the metacenter

It is obvious that if all tanks are full and the craft is heeled slightly, the fuel will have precisely the same effect as if it were a solid body having the same weight and C G as the fuel If, however, we have tanks that are not completely filled but have a free surface, as wl in Fig 8, and if the craft is heeled over to some small angle θ the fuel in the tank must adjust itself so that its surface $w'\ l'$ is parallel to the free waterline $W'\ L'$. Let the volume of either of the small wedges wsw' or lsl' be v_0 and g, g' the positions of the C G.s, and b, b' the C G.s of the whole volume of liquid in the upright and inclined positions, respectively Then, if V_0 is the total volume of liquid in the tank, we have,

$$V_0 \times bb' = v_0 \times gg' \tag{28}$$

or

$$bb' = \frac{v_0}{V_0} \times gg' \tag{29}$$

and bb' is parallel to gg'.

Now, in the same manner as we found the moment of transference of the wedges WSW' and LSL' in Fig 1 (Part I), we can find the moment of transference of the small wedges wsw' and lsl' Hence,

$$v_0 \times gg' = \rho i \times \sin\theta \tag{30}$$

where ρ is the specific gravity of liquid compared with outside water, approximately 0.70 for gasoline; i is the moment of inertia of the free surface of the liquid in the tank about a fore and-aft axis through s, and θ is the angle of heel. Substituting this value for $v_0 \times gg'$ we have,

$$bb' = \frac{\rho i \sin\theta}{V_0} \tag{31}$$

Through b' the new vertical is drawn, which intersects the upright axis at m, then,

$$bb' = bm \times \sin\theta \tag{32}$$

and consequently,

$$bm \times \sin\theta = \frac{\rho i \sin\theta}{V_0} \tag{33}$$

and

$$bm = \frac{\rho i}{V_0} \tag{34}$$

Now if the gasoline were solid, its C G would be at b both in the upright and inclined conditions, but the weight of the gasoline now acts through the point b' in the line $b'm$, and its effect on the craft is just the same as if it were a solid weight concentrated at the point m Although b is the actual C G of the liquid, its effect on the seaplane, when inclined through any angle *ever so small* is the same as though it were at the point m—called the virtual C G of the liquid This is much the same as though a pendulum were suspended at m with its bob or mass at b. On inclining the hull an angle θ, the pendulum will take the position mb'. This corresponds exactly to the action of the liquid

From this discussion we see that the C G. of the aircraft cannot be regarded as being at G, but as having risen to G_0. If W_0 be pounds of the liquid in the tank, which is the volume V_0 multiplied by density in lb. cu ft, and W

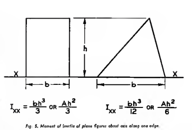


Fig 5. Moment of inertia of plane figures about axis along one edge

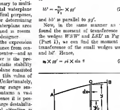
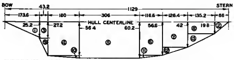


Fig 6. Moment of inertia of irregular plane figure.



COMPUTATION

1	$bh^3/12$	= 231,000 IN.^{4}	8	$bh^3/3$	= 339,000 IN.^{4}
2	"	= 45,300 IN.^{4}	9.	$bh^3/36 + [A \times (d)^2]$	= 870,600 IN.^{4}
3.	$bh^3/3$	= 289,000 IN.^{4}	10	" "	= 1,010,244 IN.^{4}
4	"	= 9,550,000 IN.^{4}	11.	" "	= 958,405 IN.^{4}
5.	"	= 22,200,000 IN.^{4}	12	" "	= 1,868,840 IN.^{4}
6.	"	= 6,680,000 IN.^{4}	13.	" "	= 1,152,200 IN.^{4}
7.	"	= 3,120,000 IN.^{4}		TOTAL	= 48,314,500 IN.^{4}

MONENT OF INERTIA/2 = 48,314,500/20,740 = 2330 FT^4

TOTAL "I" = 2330 × 2 = 4660 FT^4

Fig 7 Moment of inertia of hull waterplane area.

is the total gross weight in pounds, we have,

$$W \times GG_0 = W_0 \times bm = V_0 \text{ (lb./cu.ft.)} \times bm \quad (35)$$

and, therefore

$$GG_0 = \frac{V_0 \times \text{(lb./cu.ft.)} \times bm}{W} = \frac{V_0\, bm}{V} \quad (36)$$

as

$$\frac{\text{(lb./cu.ft.)}}{W} = \frac{1}{V} \quad (37)$$

where V is the total volume of displacement But we have seen from Eq 34, that

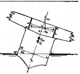


Fig 8 Diagram showing instability of free liquid surfaces.

$$bm = \frac{\rho i}{V_0}$$

therefore,

$$GG_0 = \frac{V_0}{V} \times \frac{\rho i}{V_0} = \frac{\rho i}{V} \quad (38)$$

New moment of stability at θ is

$$W \times G_0 M \times \sin\theta =$$
$$W \times (GM - GG_0) \sin\theta$$
$$= W \times \left(GM - \frac{\rho i}{V}\right) \sin\theta \quad (39)$$

the metacentric height being reduced by the simple expression $\rho i/V$

It should be pointed out here that the *amount* of liquid does not affect the result, but only the *moment of inertia of the free surface* The foregoing discussion emphasizes the necessity for adequate baffling in the fuel tanks, and the prevention of accumulated water in the hull bilges It is also apparent that the baffles should be placed in a fore-and-aft position, thus dividing the tanks into compartments with a minimum of lateral width. This is easily demonstrated by reference to Fig 9 If we assume a fuel tank where the plan view is represented by $ABCD$, its i about the fore-and-aft axis XY is, from Fig 4, $4 \times 4^3/12$ or 21 33 ft.^{4} If the lateral baffle PQ is installed, the tank is divided into two tanks $APQD$ and $PBCQ$ The total i now becomes

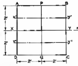


Fig 9 Representation of baffling of free liquid surfaces.

$2(2 \times 4^3)/12$ or still 21.33 ft.^{4}, the i about the longitudinal axis remaining the same However, if a longitudinal baffle is placed on XY we now have two sections $ABXY$ and $CDXY$ with fore-and aft axes $x'y'$ and $x''y''$, respectively, and the total i is now $2(4 \times 2^3)/12$ or 5 33 ft.^{4}, which is one-fourth the initial value The total reduction in BM is given by,

$$\sum bm = -\sum \frac{\rho i}{V} \quad (40)$$

for each such free surface Σbm is not negligible unless the tanks are well baffled

Erratum In Part I, Dec. '46 Aviation, diagrams for Figs. 1 and 2 were inadvertently interchanged

Jet Blade Production Difficulties Solved Via 16th Century Wax Process

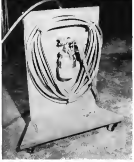
• Mass output of precision cast turbine blades is being accomplished by Westinghouse Electric Corp. through employment of wax model process originated in 1554 by Cellini

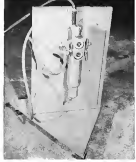
Blades were previously stamped out of hot metal by heavy forge Development of a more durable metal alloy made the blades so hard that drop-forge dies suffered excessive wear and frequently broke Other odd-shaped designs could not be mass-produced at all

Only machining now required is in making a blade master pattern. A metal die is made from the pattern, then molten wax is injected into the die to produce a wax model of pattern Twelve models are mounted on wax base and covered with metal flask into which is poured a clay and silica mixture After cement has hardened, flask is placed in oven, and wax is melted and burned away Molten cobalt-chromium alloy is then poured into cement mold, filling cavity left by wax. After cooling, cement is knocked away, and blades are finished

Compact Conveyor Speeds Spray Painting

• This small conveyor, designed and built by Ryan Aeronautical Co , has added to usefulness of spray gun in experimental and development work, in which it is frequently necessary to paint individual parts in scattered locations—away from waterfall booths and other special production facilities Having rollers for quick transportation to any part of plant, unit carries a DeVilbiss spray gun, air hose, and air regulator and filter (on rear side). Regulator is readily connected to air supply which is available through out factory.





PRACTICAL ENGINEERING OF ROTARY WING AIRCRAFT

PART VII

By JOHN E. McDONALD, *Engineering Staff, Autogiro Company of America*

Clearly analyzed in this further study of rotorcraft vibratory phenomena, are considerations of resonant oscillations in plane of rotation, blade natural frequencies, ground resonance, and critical speeds.

One mode of oscillation in the plane of rotation has already been treated in Part VI (Dec. Aviation). This mode involved synchronous displacement of all blades in a torsional sense. Other modes of far greater importance are associated with a non synchronous or off-phase swinging of blades.

In Fig. 9 are shown schematic representations of a two- and a three-blade rotor. Center of each rotor is considered to be restrained by a spring of rate K_p, which is anchored to the fixed point 0. Speed of rotation of the rotor is Ω, and the frame of reference x, y, originates at the point 0 and rotates with the rotor at the speed Ω. If an observer established on the rotating frame applies an oscillating force to the hub center he will, in general, find that resonant motions can be excited at several different forcing frequencies ω_s. These frequencies will be found to vary, depending upon the rotational speed Ω, but in every case the general nature of the excited oscillation will be the same. The hub center will move in an elliptical path (proportions of the ellipse ranging from a line to a circle) and the blades will perform an off-phase swinging. Blades of the two-bladed rotor oscillate under a phase difference of $2\pi/2$ and the motion resolves itself in a simple "V-ing" action. In the case of the three-bladed rotor, the phase difference is $2\pi/3$, and the concomitant blade motion is analogous to the voltage oscillation in a three-phase electric circuit.

At a certain rotative speed Ω, the observer will find that both hub center and blades will diverge from their equilibrium position until the blades are restrained by their root stops. Divergence remains static at this point—the frequency of oscillation $\omega_s = 0$. Such a condition corresponds to a critical speed, and to the observer on a fixed system the rotor center will appear to whirl in the direction of rotation at a frequency Ω.

In both the two-bladed and three-bladed rotor systems, there exists a relatively broad rotative speed range where hub and blade oscillations may occur without the requirement of external excitation. Such oscillations involve an elliptical hub motion and an off-phase blade motion. The oscillations are dynamically divergent, commencing at small amplitude and rapidly building up to amplitudes limited only by blade root stops. The motion is a dynamic instability and the oscillations are self-excited.

In the case of the two-bladed rotor a second region of instability is encountered in a speed range below the critical speed. The oscillation occurs at zero frequency ($\omega_s = 0$), and both hub and blades diverge in a manner similar to that occurring at the critical speed.

For derivation of equations employed in the discussion of vibration, see refs. 1 and 2.* Ref. 3 treats specifically with the response of a rotor to periodic forces. In the succeeding paragraphs, designations employed are as follows: K_p, spring restraint of pylon, assumed isotropic; M, equivalent mass of pylon. (This mass will have such magnitude that in conjunction with the spring rate K_p it will yield the observed pylon natural frequency. Total mass of pylon and blades will be $M + nm$); ω_p, natural frequency of pylon in fixed reference system, blades assumed fixed and rigid ($\sqrt{K_p/M+nm}$), ω_{γ_0} natural frequency of blade oscillation when rotor is not turning; ω_s, natural frequency of blade oscillation referred to rotating system when rotor is turning; $\epsilon' = 1 + \rho^2/b^2$; B, linear velocity damping coefficient effective at pylon support; B_γ angular velocity damping coefficient effective at vertical blade root hinge; λ, pylon damping parameter $= B/(M+nm)\omega_p$, and λ_γ, blade damping parameter $= B_\gamma/mb^2\epsilon'\omega_p$.

It will be convenient to refer all frequencies to a base frequency ω_p. Thus Ω, ω_{γ_0} and ω_s will be replaced as follows:

$$\Omega' = \Omega/\omega_p,\ \omega_{\gamma_0}' = \omega_{\gamma_0}/\omega_p$$
$$\omega_s' = \omega_s/\omega_p.$$

Natural Frequencies

For three or more blades, the equation defining the natural frequencies ω_s' (ref. 1) may be written as follows:

$$\left[1 - (\omega_s' \pm \Omega')^2\right]\left[(\omega'_{\gamma_0})^2 + \frac{a}{b\epsilon'}(\Omega')^2 - (\omega_s')^2\right] - \frac{nm}{2(M+nm)\epsilon'}\frac{(\omega_s' \pm \Omega')^4}{} = 0 \qquad (17)$$

It will prove convenient to plot ω_s' against Ω' for any specific design under study. The foregoing equation lends itself to ready evaluation with the substitution $\omega_s' = c\Omega'$, where the constant c is assigned arbitrary values.

In the limiting case of zero blade mass, Eq. 17 factors into the following uncoupled equations:

$$(\omega'_{\gamma_0})^2 + \frac{a}{b\epsilon'}(\Omega')^2 - (\omega_s')^2 = 0 \qquad (18)$$

$$1 - (\omega_s' \pm \Omega')^2 = 0 \qquad (19)$$

Eqs. 18 and 19 should be plotted on the chart ω_s' vs. Ω' since they provide useful guides in the drafting of Eq. 17. In Fig. 10—a typical frequency chart for a three-blade rotor—Eq. 18 and 19 are shown as short dash lines. It will be noted that, in general, four distinct natural frequencies ω_s' may be excited at each rotative speed Ω'. In the region A-B, however, two natural frequencies are complex numbers, and a complete analysis reveals that in this range of rotative speeds the rotor system is unstable.

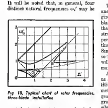


Fig. 10. Typical chart of rotor frequencies, three-blade installation

In the plotting and utilization of such frequency charts, it is essential that all exciting frequencies be referred to the rotating reference frame. Thus, a once per-revolution excitation referred to the fixed system becomes a steady force (zero frequency) in the rotating frame; a twice-per-revolution fixed frame excitation becomes a once-per revolution excitation in the rotating frame, etc.

For two blades, the equation defining the natural frequencies ω_s' may be written:

$$\left[4(\Omega')^2(\omega'_s)^2 - [(\Omega')^2 + (\omega'_s)^2 - 1]^2\right]\left[-\frac{nm}{(M+nm)\epsilon'}[(\Omega')^2 + (\omega'_s)^2 + 1] + (\omega'_s)^2 - (\omega'_{\gamma_0})^2 - \frac{a}{b\epsilon'}(\Omega')^2\right] + \frac{nm}{(M+nm)\epsilon'}[(\Omega')^2 + (\omega'_s)^2 - 1] = 0 \qquad (20)$$

The uncoupled equations, as in the case of the three-blade rotor, become:

$$(\omega'_{\gamma_0})^2 + \frac{a}{b\epsilon'}(\Omega')^2 - (\omega'_s)^2 = 0 \qquad (21)$$

$$1 - (\omega_s' \pm \Omega')^2 = 0 \qquad (22)$$

Computations are facilitated by the substitution $(\omega'_s)^2 = (\Omega')^2 + c$, where the constant c is assigned arbitrary values.

A typical frequency chart for a two-blade rotor system is plotted in Fig. 11. It will be noted that although three natural frequencies, in general, can be excited at each rotative speed, there are two ranges of rotative speeds A-B and C_1-C_2 where only one real natural frequency is apparent. In both these rotative speed ranges, the rotor system is unstable.

Ground Resonance

The phenomenon of ground resonance was first evident in the early autogiro with the advent of the vertical blade hinge. It is reasonable to assume that nearly every rotorcraft since constructed, has, either occasionally or persistently, demonstrated symptoms of this malady during takeoff or landing. Since the phenomenon is common and so frequently of a dangerous nature, it will be well to examine its physical manifestations in some detail.

As a measure of simplification let us study the ground behavior of a fictitious rotorcraft possessing such symmetry in mass distribution and landing gear characteristics that its natural ground oscillation results in a circular whirling of the rotor hub (that is, pitching and rolling mode oscillations occur at identical frequencies and with equal energies).

As the rotor is slowly accelerated from rest it will be observed that no ship motion occurs at low speeds, nor will an abrupt external disturbance result in any unstable oscillations. The operation is both smooth and stable.

At some higher rotative speed, if the plane of the rotor is appreciably angled with respect to the horizontal, a violent ship oscillation may occur, its direction of principal response lying in a plane normal to both the rotor plane and the horizontal. Simultaneously, the observer will hear a pounding noise originating in the rotor hub. Investigation will reveal that the oscillation is forced by the violent swinging of blades up against their root stops and that the origin of the blade oscillation is nothing more mysterious than the action of gravity on the pivoted blades. Fortunately, the action occurs at such low speed that normal rotor clutch engagement carries the rotor speed through and beyond this roughness before it becomes apparent to the operator. However, in the single rotor helicopter, where torque is compensated by a tail rotor, this type of oscillation must be given special consideration, and the tail rotor "idling speed" should be established at a sufficiently high figure so that the oscillation is avoided.

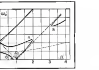


Fig. 11. Typical chart of rotor frequencies, two-blade installation.

At a higher, sharply delineated speed the hub center may proceed to whirl and the oscillation to build up to an amplitude limited only by the damping capacity of the supporting gear. In such case the frequency of the ship oscillation is found to coincide with rotor speed, and the condition is obviously one of "resonance" or one-to-one response. The vibration is analogous to that associated with the turning of a shaft at its critical speed. However, there is one important point of difference—the frequency of oscillation is not equal to the natural aircraft frequency but is considerably lower.

If the hypothetical craft has a two-blade rotor, the one-to-one whirling motion will persist until rotor speed exceeds the natural aircraft frequency, at which point smooth operation will again result. If the craft is equipped with a rotor having three or more blades, the whirling motion occurs only at the critical speed. Operation above critical speed remains smooth until a much greater rotative speed is attained.

In the speed range immediately beyond the natural ship frequency, rotor operation is smooth and stable for

(*Turn to page* 114)

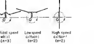


Fig. 12. Whirl patterns of three- and two-blade rotors

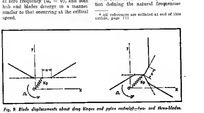
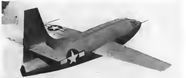


Fig. 9. Blade displacements about drag hinges and pylon restraint—two- and three-blades.

* All references are collated at end of this article, page 115

Bell XS-1 Readied For Supersonic Trials



This in-flight view of Bell's rocket-powered high-speed research plane points up stub-winged craft's rather conventional configuration. Designed for an ultimate top speed of 1 700 mph at 80 000 ft., XS-1 is not actually a tactical type but has been constructed as a flying research laboratory under a joint NACA-AAF-Bell program. (Also see Sept. 1946 AVIATION). Piloted by Chalmers, Goodlin XS-1 is transported aloft under a Boeing B-29 then released to make its brief dashes to altitude for speed runs. Specifications are given as: Span 28 ft., length 31 ft., overall height 10 ft. 10 in., wing area 120 sq. ft. empty weight 4 892 lb. (526 lb. being test equipment) rocket fuel weight 8 177 lb. and gross weight 13 069 lb. (AAF photos)

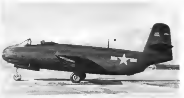
Although it presents a porcine appearance, XS-1 is a very clean craft, heavily stressed to withstand 18 Gs. An unusual feature is wing skin, which consists of aluminum alloy machined out of solid stock, giving a thickness of more than ½-in. at root and slightly more than ⅛ in. at tips. Wings are very thin, with a minimum thickness of only 10% of chord. Power plant, designed and built by Reaction Motors, is a liquid-rocket unit developing 6 000 lb. thrust (see pages 44-46 of this issue). We are informed that first XS-1 will not be capable of reaching its designed speed due to use of alternate power plant. Originally planned was a fuel system wherein alcohol and oxygen would be forced into burner chambers by a special turbo pump. However design delay prompted use of pressurized system now used, which allows an endurance of 2.5 min. at full power, compared to 4.2 min. when turbo pump is fitted. With present engine, top speed is figured at 1,000 mph. at 60 000 ft. and rate of climb as 28 000 fpm., as compared with calculated 1,700 mph. velocity at 80,000 ft. and rate of climb of 45 000 fpm. for turbo pump version.

This rear view clearly indicates rudder's height and large amount of vertical fin area employed for satisfactory stability. Noteworthy, too, is high placement of horizontal tail surfaces to avoid turbulence that might be created by wing. Flutter dampeners have been designed to minimize high-speed flight vibrations. It's expected that after initial tests have been completed, other wings of differing design will be fitted.

Two New All-Jet Fighters Join Navy's Air Arm

North American and Vought reveal initial ventures into j-p field. XFJ embodies nose intake, while XF6U features extensive use of new construction material developed by Connecticut company.

NAA's XFJ-1, powered by a GE jet of new design, employs a ram duct in nose. Of all metal construction craft spans 38 ft. 1 in., is 33 ft. 7 in. long, and 14 ft. 6 in. high. Speed is given as well over 500 mph. With engine, intake, and main fuel tanks enclosed in fuselage, it was possible to utilize very thin laminar flow wings. There has even been placement of supplemental position lights in noses of auxiliary fuel tanks at wingtips. Right: Front view shows 10 deg. horizontal stabilizer dihedral, also wide landing gear tread.



Vought XF6U-1, featuring light weight is powered by a new Westinghouse unit with intakes under wings near fuselage and exhaust beneath tail. Outstanding innovation of craft is utilization of Vought-developed Metalite (two thin sheets of high strength aluminum alloy bonded to balsa wood core) for construction of craft's wings, fuselage, and tail surfaces. New material permits major reduction in weight and drag, due to overall simplification of structure and reduction in number of external joints. Consequent highlight is stated to be elimination of skin wrinkling. XF6U's span is 30 ft. 2 in., length is 32 ft. 10 in., and height 11 ft. 9 in. Note (front view, left) that plane's cockpit canopy features unusual bulge, in contrast to conventional form. (AAF photo)

Convair Producing All-Metal L-13 Liaison

Small versatila craft, naw being turned out for AAF, tuetures falding wings and tail, also adjustabla landing geor.

A NEW JACK-OF-ALL-TRADES liaison plane has been developed by Convair under the designation L-13 and is now being turned out at San Diego to fulfill a large AAF order

Adaptabla to a large number of tasks, the new all-metal araft can be readily convertible for observation, communication, photography, ambulance, wire laying, conrier service, artillery spotting, supply dropping, aerial pickup, and light cargo work

Although the L-13 normally carries three, it is understood that its large cabin can accommodate six if necessary

Powered by a 245-hp Franklin 0-425-5 engine, the craft is stated to cruise at 92 mph, have a top speed of 115 mph, landing speed of 43 5 mph, and normal range (46-gal) of 368 mi. By using an auxiliary tank, range can be stretched to 750 mi Takeoff distance is reported to be but 230 ft, while landing run is given as 227 ft. Wingspan is 40 ft. 5½ in., length 31 ft 9 in, height 8 ft 5 in, wing area 270 sq ft Gross weight is 2,900 lb, while empty weight is 1,012 lb The L-13 can be towed, glider fashion, up to speeds of 150 mph, then released in flight to continue under its own power.

Wings are of two spar all-metal riveted construction, with aluminum alloy sheet covering Leading edge assembly is attached to the front spar The winge have a very large slotted trailing edge flap of 25-sq ft. area, 11 ft in length, with a chord of 27 in, and 25-sq ft area They can be lowered 45 deg Fixed type leading edge slots, each 96 in. long, extend along the aileron areas The wings can be folded by removing front-spar attaching bolts, thus permitting the panels to rotate with the leading edges down, about a line through the rear spar attachment fitting and the wing lift strut fitting

Horizontal tail surfaces have an area of 50 sq ft Elevators have an angular movement of 25 deg up and 20 deg down Stabilizer consists of two aluminum alloy panels of two-spar construction, bolted to fin structure and externally braced to fuselage The stabilizer can be folded vertically, thus reducing craft's overall width to 80 in.

Vertical empennage totals 23 sq ft in area, and the fin, built integral with the fuselage, is fabricated of aluminum alloy A single spar with formed ribs is used for the rudder, which is fabric covered

Fuselage consists of two sections bolted together Forward component is of conventional truss-type fabrication, being welded steel tubes, while the aft section is of semi-monocoque design The fuselage has three jettisonable doors, two on the right side and one on the left A post between the two right-hand doors is removable to facilitate loading

Tha large transparent cockpit enclosure consists of Plexiglas panels supported by steel frames, and in order to provide maximum downward vision, the windows slope outward at the top Door windows are hinged to swing outward to lie against the fuselage For protection against the sun, curtains are provided to shield each crew member Normally, seating arrangement for pilot and observer is side-by-side; however, when litter patients are carried, the crew seating is tandem Dual controls are fitted

Landing gear is of the fixed cantilever type, with tread of 92 85 in. for landing and takeoffs and with adjustment to 61 6 in for ground towing Loops are attached at each of the gear spindles to facilitate towing An attachment point for backward tows is fitted to the tail wheel axle. Hydraulic expander-tube brakes are utilized, operated from tha pilot's seat by means of toe-action pedals Instruments are mounted on shock-absorbing units, and the cabin is provided with a hot-air heater. When operated by one crew member, it's said that the L-13 is capable of carrying 400 lb of tied-down cargo. It's also possible to install a loudspeaker, message pickup assembly, and facilities for wire laying

Built to perform a wide variety of utility liaison duties, Convair XL-13 is a rugged craft designed to operate from small fields. Powered by a 245-hp Franklin turning a two-blade electrically controllable pitch prop, plane is stated to have a top speed of 115 mph. at 2,900 lb. gross weight.

THE CLOSED SHOP

Key to Labor Monopoly

IF THE PEOPLE of the United States are to loosen the monopoly control now exercised by some segments of union labor and recapture the power to control their own economic and political destiny, they must come to grips with the problem of the closed shop. A satisfactory solution of that problem is as vital to the interests of the wage earner, who should be fully protected in his right to organize and bargain collectively through representatives of his own choosing, as it is vital to the interests of the nation as a whole.

By the closed shop, which unfortunately is a term that seems to shed more heat than light, I mean any shop in which the worker must make his peace with a union in order to have a job. There are approximately 13½ million union members in the United States. Of these about 10 million are governed by arrangements calling for "closed" shops, union shops, maintenance of membership provisions and similar devices which make good standing in a union a condition to holding a job.

Such arrangements raise serious issues about what is commonly presumed to be the basic American right to work. Also, closed shop arrangements lie at the root of the dominant economic power now exercised by some labor leaders.

The problem of reducing the power of these labor leaders to proportions that make it safe for democracy is the age-old problem of monopoly. In an earlier era this problem was created largely by businessmen who sought to escape the restraints of competition by combinations or agreements to control prices and production. Such efforts are still attempted and must be curbed by law.

Union Labor Monopoly

But, after more than a decade during which a monopoly position for organized labor has been aggressively promoted by the federal government, the major monopolists today are those labor leaders who wield the power of enormous nationwide unions. About 90% of the soft coal miners do the bidding of John L. Lewis. A like percentage of the auto workers are represented by the United Automobile Workers of the C. I. O. About 80% of the production workers in steel are members of the United Steel Workers, C. I. O. No single corporation has more than a fraction of the economic power that is concentrated in these unions. And if corporations were to combine their power to cope effectively with that of these union monopolies they would unquestionably find themselves charged with violating the federal antitrust laws.

In its national sweep, the monopoly power of unions rests largely on their exemption from the federal antitrust laws. My previous editorial in this series (the 53rd) discussed the desirability of removing that exemption. The local roots of this monopoly power are often embedded in closed shop arrangements

Closed Shop in Coal

An illuminating case in point is provided by the United Mine Workers, whose leader John L. Lewis has graciously given the country a 3½-month reprieve from "the hysteria and frenzy of an economic crisis," as he himself termed it. During that latest crisis the dispatches from the soft coal fields reported that the miners were standing behind John L. Lewis almost to a man. And the implication usually was that the driving forces of the strike were loyalty to Lewis and the prospect of economic gain.

Underlying that performance, however, and basic to it was an agreement in the soft coal fields providing that "as a condition of employment all employees shall be members of the United Mine Workers." Hence to hold a job in 90% of the soft coal industry which is governed by contracts with the United Mine Workers, a miner must not offend the union. To avoid offense the union member must even be careful in criticising what his union does. *Suspension from the union for six months, and hence from the right to hold a job*, is the penalty imposed by the United Mine Workers constitution for circulating a statement "wrongfully condemning any decision rendered by any officer of the organization."

The willingness of the miners to follow Lewis until the country froze over was not, of course, exclusively a product of the agreement limiting jobs in the coal fields to union members of good standing. Some of it originated in bad handling of employee relations in the coal fields in years gone by. But the fact remains that Lewis' soft coal monopoly has as one of its principal foundations an agreement which gives the United Mine Workers a job-or-no-job hold on 90% of the soft coal miners.

In its extreme form, the closed shop not only makes union membership a condition of employment but narrowly limits the numbers admitted to union membership and hence to the opportunity to work. In this way it is used to enforce restriction of output and working rules which would never stand up under free competition.

Fair Dealing

The closed shop raises major issues of personal freedom and fair dealing between individuals. As matters now stand, closed shop agreements require employers to discharge workers who lose their good standing in the unions involved. At the same time they frequently impose no requirement on unions to grant membership to law abiding and technically qualified persons. Many unions with closed shop agreements refuse to grant membership on the basis of competence. Thus, qualified workers are denied a fair chance to hold a job.

In its dealings with the closed shop issue the federal government has been pushed into a self-contradictory position. The National Labor Relations Act (the Wagner Act) provides, and properly, that "employees shall have the right . . . to bargain collectively through representatives of their own choosing" In furtherance of that basic proposition, the Wagner Act also provides that "It shall be an unfair labor practice for an employer . . . by discrimination in regard to hire or tenure of employment to encourage or discourage membership in any labor organization . . ." Standing alone, the provision would clearly outlaw the closed shop.

But then, to favor the closed shop, the Wagner Act turns right around and provides that "nothing in this Act . . . shall preclude an employer from making an agreement with a labor organization . . . to require, as a condition of employment, membership therein," provided that certain conditions of representation are fulfilled. This places the National Labor Relations Board in the impossible position of trying to administer a law which simultaneously points in opposite directions.

In successfully contending that there should be no closed shop arrangements on the railroads, the late Joseph Eastman, Federal Co-ordinator of Transportation, said, "If genuine freedom of choice is to be the basis of labor relations under the Railway Labor Act, as it should be, then the yellow dog contract and his corollary, the closed shop . . . have no place in the picture." The so-called yellow dog contract, which requires a worker to agree not to join a union as a condition of employment, has long since been outlawed.

At one time the closed shop was defended as a protective device for feeble young unions struggling against predatory employers. But a mere glance over the current economic scene discloses that the time when that argument was supported by the facts is past. Now it is the labor leaders who frequently exercise decisive economic power.

At elections in November three more states, Arizona, Nebraska and South Dakota, passed constitutional amendments outlawing the closed shop. In doing so, they joined six other states, which, in one way or another, have restricted the closed shop. The South Dakota amendment presented the basic issue created by the closed shop in simple and direct terms when it declared that "The right of persons to work shall not be denied or abridged on account of membership or non-membership in any labor union, or labor organization."

That issue must be squarely faced by the new Congress as its first order of business, the labor crisis, is to be resolved.

James H. McGraw, Jr.

President McGraw-Hill Publishing Company, Inc.

THIS IS THE 54th OF A SERIES

In "Operation Turtle" DESIGN TURNED THE TRICK

By COMDR. THOMAS D. DAVIES, USN, And LT. HUGH L. HANSON, USNR

"If exacting patrol plane requirements are really to be met, we must tailor-make the type," decided Navy. Quickly, designers and builders set to work, Lockheed's P2V was the result, and then, in climax, both policy and design were emphatically proved—in the "Truculent Turtle's" outstanding globe-spanning performance.

NON STOP FLIGHT of the Lockheed P2V *Truculent Turtle*, from Perth, Australia, to Columbus, Ohio, demonstrated that attention to design details will pay real dividends with respect to performance.

A twin-engine aircraft, the P2V has a greater actual and potential range than any airplane of its type. This is a direct result of the specific requirements found by our Navy to be necessary for its patrol aircraft. The military possibilities of this plane are magnified when it is noted that operation is possible from moderate-sized advanced bases. Extra length runways of special length are not required.

At the start of the recent war, our Navy had no land-based patrol planes. Attempts to rework available Army planes to make them suitable for Navy patrol missions soon forced a modification program that amounted to a redesign. And then it became apparent that requirements could only be satisfied with a design originally tailored to do the job.

The naval patrol plane program initiated as a result of early experience in the war has as its development objectives the increase of the probability of detection of any patrol target and the increase of the offensive power against these search targets. The first of these objectives includes such variant qualities as long range, short takeoff, and low maintenance requirements. The patrol plane's mission is a global one, since the target which it is seeking to detect may well be anywhere on the globe, above the sea, on the sea, or beneath the sea. Tasks of the patrol plane all require very long range, but they are unique in that they all may carry its operations far afield from the theater of the war proper. In order to operate in as many geographical locations as possible, the patrol plane must be capable of operating out of the smaller fields.

Fueling of "Turtle's" starboard wing-tip gas tank as plane was readied for takeoff at its Australian base. In its record non-stop flight from Perth, Australia, to Columbus, Ohio, the Lockheed-built P2V Neptune Navy patrol plane surpassed 11,000 mi. in a time of 55 hr. 17 min. Craft is powered by two Wright Cyclone C-18 R-3350-8 engines turning Hamilton Standard Hydromatic propellers. (Official U. S. Navy photo)

Accordingly, P2V design was specifically initiated to obtain a plane that would fill the pertinent requirements for patrol activities. Result was a twin-engine craft with an efficiency unattainable in four-engine designs. Moreover, the P2V, as designed by the group under Mac Short of Lockheed, incorporates excellent maintenance features. Particularly, it has the low speed characteristics which enables it to get in and out of small fields, yet it has a high cruising speed and a top speed well in excess of 300 mph.

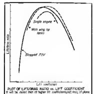
The P2V was tested as a wind tunnel model by the Ames Laboratory of the National Advisory Committee for Aeronautics. Splendid service was performed by NACA personnel, employing the 7 x 10 tunnel. They obtained detail test data in time to be of great assistance in the actual design.

Contrary to popular opinion the P2V does not have a radically new wing design. The wing root section is a modified NACA 2400, and the tip section is an NACA 4400 series airfoil section. These sections are not new, but they do have excellent low-speed characteristics.

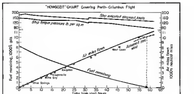
Essentially full-span flaps are obtained through the use of aileron droop. This flap and wing combination enables the P2V to leave the ground after a run of less than 1,000 ft. at the design gross weight of 45,000 lb. (zero wind conditions).

The broad usable C.G. range specified for the design was obtained through employment of a variable-camber horizontal stabilizer. This idea, while not new, has proven to be a highly satisfactory device for adjusting the trim for a wide range of loading conditions.

The combination of wing, fuselage, and nacelles is an optimum. The 6.5-deg. down tilt of the engine nacelles results in a nearly horizontal thrust line at lift coefficients corresponding to cruising speed, while providing for increased low-speed stability. The nacelles themselves are exceptionally "clean," and what is more important, they provide such excellent cooling characteristics that the *Turtle* was able to climb at 475 fpm, using normal



PLOT OF LIFT/DRAG RATIO vs. LIFT COEFFICIENT. It will be noted that at higher lift coefficients the net drag of plane with wing-tip tanks is actually less than that of "clean" airplane



rated power with closed cowl flaps, at a gross weight of 85,500 lb.

For purposes of the record flight, original plans called for use of 600 gal. wing tip tanks. It will be noted from the accompanying curves that at higher lift coefficients the net drag of the airplane with tip tanks is actually less than that of the "clean" airplane. This of course is due to the effect of shielding the wing tips, giving a reduction in the induced drag as a result of effectively increasing the aspect ratio of the wing. However, it was found that the 600 gal. tip tanks made the wing structure critical for the ground condition, hence 300-gal. tanks were employed instead.

These smaller tanks were costing less than 3 knots in cruising speed at the time they were dropped. The additional feature of the tip tanks was to provide a more favorable wing bending moment distribution for the flight condition. Hence fuel was first used from the fuselage tanks.

As designed, the P2V has a very large fuel capacity. For the record flight, however, a nose tank was installed in place of the six 20 mm. cannon, and extra tanks were also installed in the fuselage in addition to the tip tanks, giving a total capacity of more than 8,600 gal.

Evening was chosen for time of the takeoff, for two purposes: To take advantage of the cooler, higher density air, and to minimize the structural loads resulting from air turbulence while flying over the Australian continent. The total gross weight at takeoff was 85,500 lb., nearly 60% of which was gasoline. The takeoff was made on a 6,000-ft. runway, and the plane was airborne with ease after a run of 4,720 ft. To provide an additional safety factor the plane was allowed to attain a speed of 20 knots above the speed necessary for takeoff. The four 1,000-lb. thrust, 12 sec. Jato units were not set off at the point to give minimum takeoff distance, but instead were started near the end of the run to enable the P2V to gain altitude rapidly. The wheels were nearly retracted by the time the jets had finished firing. Actually, it would have been quite possible for this plane to take off in about 3,500 ft. at this same 85,500-lb. gross.

Prior to the flight, the details of engine operation were carefully worked out for a range of temperatures and altitudes. Torquemeters are standard in the P2V, and it was therefore possible for the pilot to operate at or near the maximum engine efficiency. Throughout the flight, adjustments were periodically made to account for the variation in lift coefficient resulting from the continuous weight change. The accompanying Howgozit Chart gives an excellent picture of the entire flight with reference to the variable operating conditions.

As mentioned previously, the fuel was initially used from the fuselage tanks, so as to retain the beneficial bending moment effect of the tip tanks at the high gross weights existing during the early portion of the flight. The tip tanks were dropped shortly after the plane reached the point where the net drag with the tip tanks was appreciable more than the net drag of the airplane in the "clean" condition.

It will be noted that the lift/drag ratio curve indicates a single-engine operating condition. Single-engine operation was originally contemplated as a means of further increasing the range. This means of getting additional range was not employed during the flight, however, because the safety factor in case of engine failure was considered more important.

Avigation was based on the use of celestial methods combined with normal radio aids. In addition, some use was made of the pressure pattern method. However, this latter method was seriously limited by weather conditions, which forced the aircraft to be flown at an altitude above the range of the radio altimeter. Celestial sights were computed rapidly by means of a new graphic spherical triangle solver.

In attempting to keep personnel fatigue to a minimum, the philosophy was adopted of trying to duplicate, insofar as possible, a normal existence. To this end the plane was well equipped with washing, shaving, and sleeping facilities. Food, equal to that normally consumed, was prepared with hot plate facilities. No "anti-sleep" tablets or any drugs were used, and no fatigue troubles were experienced, even though the last 25 hr. of the flight were flown at 17,000 ft.

Unfortunately, the *Truculent Turtle* did not attain its ultimate objective (Bermuda) because of headwinds, icing, and other adverse weather conditions. However, it did reach Columbus, Ohio—a great circle distance of 11,236 mi.—and in so doing it set a new record for non-stop long distance flying, as well as a weight lifting record for twin-engine aircraft.

DATA ON RECORD "TURTLE" FLIGHT

Perth, Australia, to Columbus, Ohio

(Sept. 29-Oct. 1, 1946)

Time	55 hr, 17 min.
Great circle distance, statute miles	11,236
Ground statute miles	11,500
Air statute miles	11,665
Av. speed, mph. (11,665 mi.)	211
Av. miles per gal. (11,665 mi.)	1.41
Av. headwind, mph	4.0
Takeoff gross wt., lb	85,500
Fuel load, gal	8,396
Fuel percentage of gross wt.	58%
Wing loading, lb. per sq. ft.	85.5
Takeoff distance, ft.	4,720
Power used for takeoff	2 x 2,300 hp., plus four 1,000 lb. 12-sec. Jato units.

FRENCH PLANE INDUSTRY ACCENTS VARIETY

By MICHAEL MARSH, *McGraw Hill World News*

Aircraft production is seen running the gamut from small jet-craft through large civil transports and military types. Shortage of aircraft materials and tooling persist, but plane manufacturers are maintaining stability by making other products.

FRENCH PLANE MAKERS have developed a host of new types of large aircraft since the liberation, and quite a few of these have now progressed beyond the prototype stage and into production. With these new models, French aviation—knocked almost completely flat during the war—hopes to regain a place in the postwar world.

New French planes can be divided into three classes. A number of new models are being turned out for civil air transport; at least two large experimental craft have been developed; and in the military sphere it is known that a few new planes are in process. Some are adaptations of German designs, but the great majority are of domestic conception, according to the Ministry of Armament, which controls the major French plane plants.

Most striking of the transport planes are two slightly different types of 79-ton six-engine flying boats, the Latécoère-631 and the SE-200. Prototypes of both of these models were designed in 1942, but the Laté-631 is only now in production, and only two SE-200s have so far been completed.

The Laté-631 and the SE-200 resemble each other in all essential particulars. Each is powered by six Wright Double-Row R-2600 engines, generating 1,600 hp. each at takeoff. Cruising speed at 9,842 ft. when fully loaded is stated to be 200 mph. Top speed at 11,925 ft. is 250 mph. These performances compare favorably with Martin Mars speeds attained with four 2,300-hp. Wrights, or the Short Shetland with four 2,500 hp. Bristol engines. Range of the planes, at cruising speed and with a 37-mph. headwind, is set at 3,750 mi.

Laté-631 has a wing span of 225 ft., length 170 ft., height 40 ft., and wing area 3,780 sq. ft. The SE-200 is slightly smaller.

Inside, the planes can be fitted for 80 seated passengers or 40 in berths. The Laté-631 has a crew of nine, the SE-200 a crew of eight.

Electrical current in the Laté is provided by a 3-kw. Leece-Neville generator attached to each engine, in addition to four similar auxiliary generators run by two four-cylinder Simca water cooled motors. Three radio sets are provided, each working different bands.

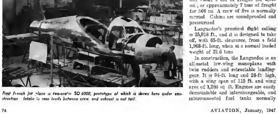
The SE-200 is planned chiefly for North Atlantic service, the Laté-631 for flights from France to South America. Unfortunately the first Laté in operation, the "Lionel-de-Marmier", suffered an accident late last year while on a survey trip to Argentina and other South American countries. As explained by the Armaments Ministry, one of the propellers broke off, and before the pilot could shut down the power, the engine tore itself to pieces and crashed into the fuselage, with fatal results to several occupants. Pieces of the prop are still being studied, and meanwhile the factory is continuing to produce the planes without modification. Official French opinion is that the accident was wholly fortuitous.

Air France has so far been able to provide Paris-Buenos Aires service with Douglas DC-4s, without sleeping accommodations, on a 60-hr. instead of a 48-hr. schedule. It is not certain whether three of the Laté-631s ordered by the Argentine FAMA will be accepted.

An all-around transport for intermediate distances has been developed by SNCA Sud-Est, the SE-161 or Languedoc. This craft has a cruising speed of 230 mph., and a top speed (at 7,545 ft.) of 267 mph., using four Gnome-Rhone 14 N 44-45 engines with a total of 4,360 hp. at normal cruising. Pay load can be varied as follows, according to range and assuming a 37-mph. headwind: 33 passengers and approximately a ton of freight for 620 mi.; 24 passengers and about a ton of freight for 930 mi.; 10 to 12 passengers and about a ton of freight for 2,000 mi.; or approximately 7 tons of freight for 500 mi. A crew of five is normally carried. Cabins are soundproofed and pressurized.

Languedoc's practical flight ceiling is 25,918 ft., and it is designed to take off, with 65-ft. clearance, from a field 1,968-ft. long, when at a normal loaded weight of 21.6 tons.

In construction, the Languedoc is an all-metal low-wing monoplane with twin rudders and retractable landing-gear. It is 94-ft. long and 24-ft. high, with a wing span of 115 ft. and wing area of 1,200 sq. ft. Engines are easily demountable and interchangeable, and interconnected fuel tanks normally carry 1,900 gal. Flaps are pneumatically operated; ailerons electrically.



First French jet plane is two-seater SO 6000, prototype of which is shown here under construction. Intake in nose leads between crew and exhaust is out tail

SNAC Centre constructed NC-3021 Belphegor for high altitude research. Powered by German Daimler-Benz 610, it's said to have a ceiling (when stripped) of 41,994 ft. Intake below engine cowl supplies air for cabin pressurization

SE-161 Languedoc is slated to play an important role in Air France's intermediate routes. Ten to 33 passengers may be carried in addition to freight, and top speed is stated to be 267 mph. A pressure cabin is fitted.

Air France ordered 25 of these planes for delivery in 1946. The first, delivered in May, has been put on the Paris-Algiers run; others will take over additional North African flights, the Paris-Stockholm route, and the Paris-Madagascar run.

A smaller mail or passenger plane (SO-94) has been developed by SNCA Sud-Ouest and is now in production. Twenty-five have been ordered by Air France. Designed to carry 10 passengers and 450 lb. of baggage for 1,200 mi., or 2 tons of mail for 750 mi., the SO-94 is powered by two Renault 12-S-00 engines of 490 hp. each at 7,837 ft., giving a cruising speed of about 240 mph. Top speed is 265 mph. Including the crew of two, normal loaded weight is 6.8 tons when carrying mail, or 6.1 tons when carrying passengers. Gas consumption is figured at about 60 gph. Dimensions of the plane are: Span 64 ft., length 48 ft., height 16 ft., wing area 352 sq. ft. Ceiling is about 22,000 ft. For passengers' comfort, the cabin is heated and soundproofed.

For use on the same type of service as planned for the SO-94, the SNAC Centre company has perfected a plane derived from German designs and known as the NC-702. The Nazi version was the Siebel Si. 204D. This low-wing duralumin monoplane, using the same two Renault engines as the SO-94, is slightly larger than the latter and somewhat slower. Dimensions are: Span 83 ft., length 50 ft., height 17 ft., wing area 497 sq. ft.

Bearing eight passengers, with baggage, and a crew of two—thus bringing total weight to 6.1 tons—the NC-702 has a cruising speed of 202 mph. and a top speed of 217 mph. at 9,842 ft. Normal cruising range is 670 mi. with about 220 gal. of fuel, but two auxiliary tanks containing 120 gal. are available, increasing the range to 1,240 mi. Fuel consumption is estimated at about 50 gph. under normal conditions. Engines are demountable and can be changed by three men in half an hour.

Sturdiness of the NC-702 was demonstrated in a recent successful flight of the first of this model over 16,700 mi. of Africa. At one point, forced down by heavy storms between Elizabethville and Stanleyville, the craft made a successful landing on—and a successful takeoff from—a short emergency landing strip deep in the jungle, using only 440 yd. of the 660 yd. strip. Air France has ordered six of these planes.

Of even more interest than the new French transport planes are the various experimental craft now being tried out. Five SO-6000s, a small jet plane designed and produced by SNCA Sud-Ouest, are to be made, each with a different turbojet engine. The first model, powered by a Jumo 004 reconstructed and modified in France, had its tests in Aug. The second model will use a Rateau A-65 turbojet, the third a Rolls-Royce Nene 1 produced under license by Hispano-Suiza, and the fourth and fifth will probably use American jet engines if licenses can be obtained.

The SO-6000 has the following dimensions: Span 36 ft., length 41 ft., height 12 ft., wing area 151 sq. ft. With the Rateau turbojet it has an estimated maximum speed under full power of 620 mph., or a maximum speed with economical use of fuel of 548 mph. Takeoff climb is set at 76 fps., landing speed fully loaded at 91 mph., and landing speed stripped down at 81 mph. Weight of the craft fully loaded, including 1,950 lb. of useful load, is 3.9 tons. A retractable tricycle DOP landing gear is used.

An air intake in the nose passes straight back into the turbine. Above the intake, and just in front of the turbine, sit the two crew members. The hot gas passes out the rear of the fuselage. Entrance of the gas into the exhaust nozzle is regulated by a patented apparatus designed to pass the gas smoothly and prevent any throttling or explosions. The turbine is put in operation by a field starter.

Several other French jet planes are under construction or in the plan stage, but details are not yet available. Included among them are the NC (Centre)-260 and the N (Nord)-1600.

Rateau's A-65 turbojet engine is 9.36 ft. long, and has a maximum dia. of 4.88 ft. It has nine combustion chambers and weighs 1,760 lb. dry. At sea level and at 560 mph. it produces 2,600 effective hp., representing a thrust of 1,716 lb. at 7,450 rpm. Total power absorbed by air compression is equal to 6,400 hp., broken down into 5,360 hp. absorbed from primary air, 992 hp. absorbed from secondary air, and 48 hp. of mechanical loss. Gas temperature reaches 850 deg. C. At the point of expulsion from the tail pipe, allowing for heat and mixing losses, pressure is 24.6 psi. at 397-deg. C.

Another experimental plane was being tested in France in August. Built by SNCA Centre for stratospheric flight and for scientific research into cosmic waves, it is known as the NC-3021 or Belphegor.

Belphegor has a normal ceiling of 38,057 ft. and, when stripped down, a ceiling of 41,994 ft., according to calculations. A single Daimler-Benz 610 engine and a four-bladed 17.6-ft., propeller are fitted, giving 3,000 hp. at sea level and 1,000 hp. at 39,369 ft. Maximum speed is 340 mph., cruising speed is 255 mph., and the ship can take off in 470 yd., climbing to 36,089 ft. in 38 min.

Structurally, the Belphegor is composed of three sections: A forward, or engine section; a middle tubular cabin section made of duralumin; and a rear section of wood. Breakdown of the different materials used is: 5% steel, 30% wood, 60% duralumin, and 5% various. Total loaded weight, in-

In production, Latécoère 631 is furthest developed of several large aircraft in France. Grossing 79 tons, and powered by six 1,600-hp Wright Cyclones, craft is said to have 250-mph top speed

In same class as Laté-631, but of later design is this SE-200, slated for North Atlantic operations. Craft can carry 80 seated passengers or 40 in berths and a crew of eight.

cluding two tons of fuel, is 11.4 tons.

The cabin—a tubular section 6.6 ft. dia. and with about 400 cu. ft. of space—is formed by a double metal envelope with the two sheets spaced by longitudinal beams. The double skin serves the two-fold purpose of preventing escape of air and heat. The inside of the outer skin is flocked to add further protection.

Air pressure is maintained by means of an intake below the engine, leading into air compressors of the NC-41 type, which are operated directly by the engine. Heat is provided to the cabin by running a large pipe across the engine's main exhaust pipe, with hot air distributed at judicious points in the double envelope.

Observation posts are provided by a bubble on the top of the fuselage and a Plexiglas section on the bottom. Dimensions of the Belphegor are: Span 87 ft., length 66 ft., height 24 ft., wing area 540 sq. ft.

Another high-altitude plane, which the Germans had developed to the plans stage, has been produced in France by Sud-Ouest, and is designated the Heinkel He-274. Using four Daimler-Benz 603 AP engines, which develop 1,510 hp. each at normal cruising height of 18,700 ft. and at 2,500 rpm. this craft has a span of 172 ft., a length of 88 ft., and a height of 22 ft.

Turning to the military, French official sources are not overly communicative about describing what they have under way. This is partly because appropriations for military craft have been deeply slashed since last year, and also partly because the field of military aircraft is in such a state of flux that officials feel it wise to experiment a while before undertaking a large production program.

One large flying boat, the Breguet 730, has been taken over by the Naval Air Force as a patrol bomber. This craft is powered by four Gnome-Rhone 14N engines of 1,000 hp. each and weighs about 30 tons loaded and about 17 tons empty. Carrying a ten-man crew, the plane has a cruising speed of 198 mph. at 4,721 ft. It can fly 25 hr at a speed of 170 mph., or as much as 30 hr. at that speed in an emergency.

A new two-engine torpedo-bomber known as the MB-175 is being produced by the Chateauroux factory. The Chatillon plant is experimenting with a fighter with two engines in tandem, known as the VB 10. The first model was powered with Hispanos generating 1,250 hp. each, but the second will carry two Jumo-213 engines, as modified by the plant, furnishing 2,000 hp. each.

So far as output is concerned, the situation is still in flux. Right after the liberation great efforts were made to repair damaged factories, obtain a supply of raw materials, and boost the output of military planes. These efforts (as reported in May '46 issue of AVIATION) were remarkably successful. Aircraft production has climbed steadily from the low average of 21 planes a month in the Fall of 1944 up to 190 planes in May 1946. This is still below the average of 420 planes a month produced in the first five months of 1940—the highest level France has reached.

Apart from the difficulties of assembling tools and materials, a major reason why output has not climbed higher is the familiar one of government cutbacks. Military budget slashes in the last year have reduced the number of planes ordered by 1,700.

Facing this problem, Charles Tillon, Minister of Armament, turned considerable parts of the nationalized plane factories to producing other needed goods, which are made on subcontract or for the open market. By this means nearly the whole staff of 95,000 workers—far fewer than the 220,000 employed in 1940—has been kept at work. As a result, a French plane factory today is apt to present a very mixed appearance.

At the Suresne plant of SNCA Sud-Ouest (formerly the Farman works), cited as a typical example, the same building where SO 6000s, SO-94s, and the He-274 are turned out also has a section fabricating light-metal bodies for trolley-buses. In the plant's carpenter shop, household furniture is being built. Household furniture of flocked duralumin is also being turned out by the factory, as well as baby carriages.

Other plants produce tractors, buses, pots and pans, light-metal iceboxes, lockers, and office furniture, as well as carrying on their normal work on planes. Eventually all the factories hope to re-convert 100% to planes.

In another way, too, French aviation is in transition. After the liberation a number of important plane and engine plants were nationalized, and the five major companies which came under State control in 1936 have had that control turned into complete nationalization. However, there still remain a large number of independent makers of propellers, landing gear, and other equipment. These societies are criticized by some plane-makers on several grounds.

First, there have been accidents traced to faulty propellers or landing gear. Second, some planes have had to wait a considerable time for such equipment. Third, and most important, there is such a multiplicity of different designs for equipment and equipment parts, that original fabrication of equipment and eventual replacement of parts is difficult. For example, there are nine different landing gear makers, each with its own research staff. Not only does each new plane generally have a specially designed gear, but sometimes one new plane may be produced with as many as four different versions of landing gear. As far as replacement parts are concerned, standardization is reported only at a minimal stage, and lack of standardization extends all the way back to the steel mills in some cases, hitting the equipment companies as well as the plane makers.

SHEET NUMBER	D-37 (Continued)
CLASSIFICATION	Processes
SUB CLASSIFICATION	Quantities

Conversion Factors (General)

PART V

Unit	Multiplied by	Equals
Qt (U. S. dry)	67.2006	Cu. in.
Qt (U. S. dry)	1.1012	L
Qt. (U. S. liq.)	946.358	Cu. cm
Qt. (U. S. liq.)	57.749	Cu. in
Qt. (U. S. liq.)	0.9463	L
Sq. cm	0.001076	Sq. ft.
Sq. cm	0.1550	Sq. in
Sq. ft.	929.034	Sq. cm
Sq. ft.	0.09290	Sq. m
Sq. in.	1,273,240	Circ. mils
Sq. in	6.4516	Sq. cm
Sq. in.	1 × 10⁶	Sq. mils
Sq. m.	10.7639	Sq. ft.
Sq. m.	1550.0	Sq. in.
Sq. mm	1.27324	Circ. mm.
Sq. mm	0.001550	Sq. in
Sq. mm.	1973.5	Cir. mils
Sq. yd.	1296	Sq. in
Sq. yd.	0.83613	Sq. m
Tons (long)	1016.047	Kg
Tons (long)	2240	Lb.
Tons (long)	1.016047	Tons (metric)
Tons (long)	1.120	Tons (short)
T. (long)/sq. in	1.5755	Kg./sq. mm
Tons (metric)	1000	Kg
Tons (metric)	2204.62	Lb. (Av.)
Tons (metric)	0.984207	Tons (long)
Tons (metric)	1.10231	Tons (short)
Tons (short)	907.1846	Kg
Tons (short)	2000	Lb
Tons (short)	0.892857	Tons (long)
Tons (short)	0.907185	Tons (metric)
T. (short)/sq. in.	1.406131	Kg./sq. mm
Watt	1	Joules/sec
Watt	0.860	Kg. cal./hr.
Watt	3.4128	Btu/hr
Watt-hr. (Int.)	1.0003	Watt-hr. (Abs.)
Watt/sq. cm./°C	0.239	Cal./sec./sq. cm./°C
Watt/sq. cm./°C	1761	Btu/hr./sq. ft./°F
Watt/sq. cm./cm./°C.	0.239	Cal./sec./sq. cm./cm./°C
Yd.	91.4402	Cm
Yd.	0.914402	M

Courtesy Reinhold Pub. Corp., *Metals & Alloys Data Book*, by S. L. Hoyt.

GRUMMAN'S NEW MALLARD HAS NOVEL REFINEMENTS

PART I

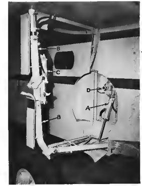
IN ADDITION TO OFFERING wide utility as a private craft, transport landplane, and seaplane, the Grumman Mallard is representative of the trend toward better design. Revealed in this amphibian are noteworthy improvements in several specific categories, as follows

Main Landing Gear

In this installation two hydraulic cylinders are uniquely employed to assure positive actuation—the downlock cylinder affording boost for the main actuating cylinder at the interval of latter's lowest mechanical advantage.

To initially start retraction of the gear, the main cylinder (A)—shown in Fig 1—must apply extreme load to overcome over-center position of linkage on main shock strut (B). To alleviate this difficulty, downlock cylinder (C) is provided with auxiliary linkage to automatically break strut (B) simultaneously with its (C's) unlatching motion. Main cylinder (A) is thus able to perform the retracting operation without fighting the dead-center position of landing gear's geometry. Dashpot bumper (D) effectively cushions strut as it is nested into wheel well.

In reverse operation, main cylinder extends strut to full length, and downlock, in pushing lock home, again provides boost for snapping strut past dead-center. In this position, strut reacts as a rigid column not dependent on hydraulic pressure to hold it extended.



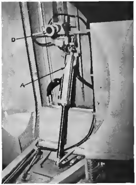


Fig. 1. Main landing gear installation of Grumman Mallard: (A) main hydraulic cylinder, (B) strut, (C) downlock cylinder, and (D) dashpot bumper. Downlock cylinder aids main cylinder at point of latter's lowest mechanical advantage. Fig. 2. Closeup showing main actuating cylinder (A) and dashpot bumper (D) for cushioning wheel. (AVIATION staff photos by E. J. Bulban).

Closeups of the landing gear mechanisms are shown in Figs. 2 and 3.

Cockpit Details

Pilot's control wheel may be "thrown-over" for use by co-pilot, and to provide for dual control arrangement, an auxiliary control wheel, normally stored under co-pilot's seat, may be quickly installed via snap-on fitting at rear of control post (Fig. 4). With auxiliary wheel detached, there is unobstructed access to bow compartment entrance directly in front of co-pilot's seat.

To provide easy passage to or from pilot's or co pilot's seats, inboard arms on each seat are hinged for folding out of way by slight lift and push to rear. Mechanism comprises sleeve hinge on seat tubular framework, supported and positioned by a sleeve cam.

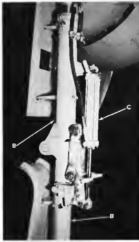


Fig. 3. Closeup depicting strut (B) and downlock cylinder (C).

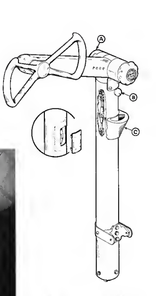


Fig. 4. Control column and wheel installation. Auxiliary wheel for co-pilot is quickly attached via snap on fitting at (A). Pilot's wheel may be thrown over by pressing down on button (B). Ash receiver is seen at (C).

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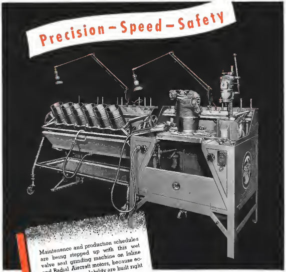

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New Instrument System Proposed For Flight and Landing Safety

By HAGAN L. JACKSON, *Engineering Department, Industrial Electronics Div., Westinghouse Electric Corp., Baltimore*

Weather-flying aid would incorporate cockpit screen system to guide plane cross country, "key" the landing operations, and spot position and course of adjacent aircraft. Use of ground radio markers would reduce weight and complexity of plane-carried equipment.

The following proposed aircraft navigation system* provides three forms of aid required for safe operation of commercial and private aircraft under adverse weather conditions. Installation of a relatively simple instrument in the aircraft, together with radio beacon transmitters on the ground and aircraft, provides the pilot with visual indications enabling him to make an instrument landing, to avigate his aircraft cross-country, and to know the disposition of adjacent planes in the air in order to proceed with safety.

Basis of System

Low-powered radio transmitters are called for to outline airfields and landing strips, to indicate cross-country routes, and to provide indications of the presence of other aircraft. With these transmitters incorporated and operating, the instrument would give a visible map of these transmitters on a cathode-ray tube installed in front of the pilot.

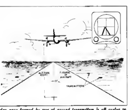
By observing the position of these transmitters on the cathode-ray tube, the pilot can direct his craft in very much the same manner as if the individual transmitters were beacon lights visible below. For, stated simply, this system gives essentially the same indications as would be provided by beacon lights. Consequently, the pilot will not require extensive special training to accustom himself to the system.

Adapted from airborne radar, the equipment carried consists of a lightweight radio receiver and indicator, plus directional antenna with a 5-deg. receiving beam. Featuring a very narrow field of reception, this antenna rapidly scans the area ahead of the aircraft. When a transmitter is located in the direction the antenna is pointing at any instant, an indication appears on the cathode-ray indicating tube at a corresponding point, thus showing the relative direction of the transmitter from the aircraft. For anti-collision warning, three small, lightweight, low power transmitters are fitted on the craft.

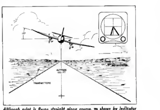
Effect of the instrument in the aircraft will be to depict, in the form of a map, all transmitters located in a conical area of 180 deg. extending ahead. Transmitters used to outline the airstrip on an airfield make the strip visible. And transmitters located in a row across country appear on the pilot's indicator as dots which he can follow as accurately as he could beacon lights on a clear night.

Likewise, transmitters located on other aircraft will be seen on the indicator in such manner that the pilot can know the location of the other aircraft with reference to his own. All of these indications will be continuously visible to the pilot (once the equipment is turned on) without adjustments, without switching from one type of service to another, and without any form of attention on his part.

* Presented before Electronic Subdivision Advisory Group on Air Navigation, Feb. 1946. It is emphasized that system is merely in consideration stage.



Wedge apex formed by row of ground transmitters is off center in pilot's indicator (upper right), showing that he is not heading directly along course. However, termination of legs of wedge symmetrically at bottom of indicator shows that he is over course.



Although pilot is flying straight along course, as shown by indicator wedge apex centered on screen, he is flying with one wing down, indicated by asymmetry of legs of wedge. Other indications show nose up or down, also presence of obstacles.

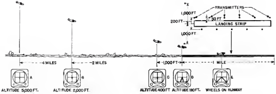


Fig. 1. Transmitters located about landing strip form patterns on pilot's indicator similar to patterns formed by ground lights.

Instrument Landings

Use of the system for making instrument landings is shown in Fig 1, where an aircraft is depicted making an approach and landing on a field equipped with the system. Shown in conjunction are the indications the pilot will see during the procedure, in any type of weather.

As the pilot approaches, he first locates the field and the airstrip by the configuration in Indication A. Merged dots which represent the transmitters at the start of the airstrip show the pilot that he is approaching from the proper direction. And the point of the small wedge, when located at the center of the indicator, tells him he is headed directly for the strip. This wedge becomes more pronounced as the pilot approaches the field, as shown in Indications B, C, and D. The pilot keeps the center of the wedge in the center of the screen, showing direct heading and approach in a level condition. These indications are similar to what a pilot would see while approaching a beacon marked field during good visibility.

Transmitters along the side of the strip appear as a line of lights would be seen on direct observation, while the two transmitters located on a line with the start of the strip give additional guidance in the form of definite indications of altitude and distance. These transmitters marking the start of the landing strip disappear from the face of the cathode-ray tube as the aircraft comes over the strip, thus indicating to the pilot that he may set his craft down. Distortions in the normal pattern show errors in glide angle, heading, and whether craft's wings are level.

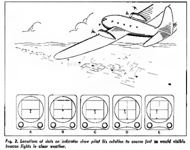


Fig. 2. Locations of dots on indicator show pilot his relation to course just as would visible beacon lights in clear weather.

Cross-Country Instrument Avigation

Fig. 2 shows how the system indicates that the pilot is on or off course when flying cross-country on instruments. Actually, the pilot follows a line of radio beacons made visible on the face of his indicator. Indications A and B show that the pilot is on course. Indication C depicts a similar picture at a higher altitude. And Indication D shows that the aircraft is over the course, but not properly headed to stay on it. The pilot simply flies his aircraft so that the row of transmitters appears along the vertical center-line of his screen. Indication E shows the pilot headed parallel to the course, but flying to one side of it.

The course does not necessarily have to be straight, as it does when radio beam indications are employed. Curvatures in the course show up as corresponding curves on the face of the indicator. The pilot is thus enabled to follow along without difficulty, for he is visually apprised of the turning points.

Two methods of laying out cross-country courses can be employed: The transmitters of one course can be tuned differently from those of another, and the pilot may accordingly tune his receiving equipment for the course he desires. The other system is to have all transmitters on the same frequency, and to employ extra transmitters, at junctions of different routes, located so as to form a coded pattern enabling the pilot to identify his position, and to turn in the right direction. The pilot could get details of this coded indications as part of his route information before flight. For example, he would simply follow the course until he came to a branch identified by four transmitters arranged in the form of a square, he would follow either leg of the course he desired and know exactly where he was at all times. Differing arrangements of transmitters could be used to identify other junctions, cities, and additional landmarks.

Anti-Collision Warning

Three transmitters, located on an aircraft, provide a warning to other pilots of the presence of the craft and indicate when possibilities of collision exist. Two of these transmitters are located on the wings, a fixed distance apart, and the third goes on the tail. Fact that the two transmitters on the wings are a fixed distance apart enables the pilot to judge his approximate distance to the approaching craft. In association with the wing dots, the dot formed by the transmitter in the tail of the other aircraft permits a rough determination of the plane's course. If the tail dot is centered between the wing dots, the aircraft is headed directly toward or away from the pilot —*i e*, *toward* if the dots tend to separate, and *away* if they tend to merge.

On the other hand, if the tail dot is to one side of the wing dots, the aircraft is flying at an angle. Of course, the receiving plane could be *approaching* another aircraft from the side and secure a similar indication. However, this would be noted—for the other aircraft would pass rapidly across the screen of the indicator and disappear. Behavior of the indication on the screen will inform the pilot when danger of collision exists, and so he can avoid it.

The transmitters required are very small, low-powered, high frequency units of a type which are permanently tuned, and which require little attention once installed. Power requirements are very low because only short-range transmission is necessary. Also, only minimum space is needed. Transmitter units installed for anti collision warning are even smaller than the others, because they are located free from interference and are not required to cover a great range.

The cathode-ray indicating instrument could be built into the instrument panel of the aircraft, and controls could be incorporated thereon. The receiving set could be located anywhere in the aircraft, and the antenna assembly could be mounted in the nose of the craft, or in a small blister on the underside of the fuselage toward the front of the aircraft.

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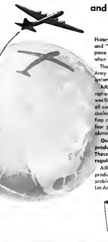

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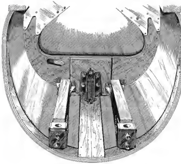
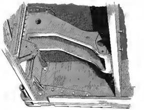
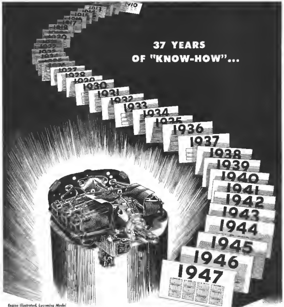


Looking aft toward tail cone of deHavilland Hornet. Seen are plywood skin and bulkheads and, in foreground, combination wood metal arrester hook reinforcement.



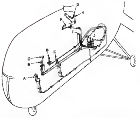
View up into deHavilland Hornet wing, revealing metal structure set in wooden wing for reinforcement at location of hydraulic jack used to fold outer wing panel up and over fuselage.



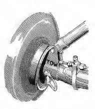
Engine illustrated, Lycoming Model O-435A. Normal rated 190 BHP

Adel landing gear used on Globe Swift retracts into well just ahead of main spar. Designed for load factor of 4.33 on 1,750-lb. plane, this gear accommodates standard 6.00 x 6 tires mounted on spot-type wheel drums

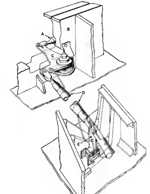
Closeup sketches of Firestone G & A XR-9B helicopter, showing details of landing gear steerable nose wheel with its tow hook (above), and main gear, with its tow hook (below).

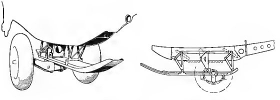


Phantom view of XR-9B engine control system, with (A) forward throttle, (B) mixture control, (C) clutch-brake lever, (D) carburetor air control, (E) aft throttle, (F) clutch-brake torque tube, (G) brake actuating lever, (H) clutch actuating lever, (I) cold air intake, and (J) carburetor.



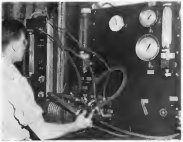
Changeover and rocker lever for aileron in left wing of Messerschmitt Me-163. Push-pull rod (A) from cockpit extends out into wing ahead of front spar (B), operating through bellcrank (C) to fore-and-aft push-pull rod (D), which goes through rocker lever (E).





Landing gear of Messerschmitt Me-163 is shown in diagrammatic view at right above and in perspective at left. Wheels were dropped after takeoff, and skid retracted up against fuselage belly for flight, being extended for landing

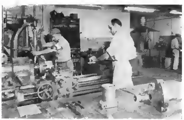
Southwest Airmotive Builds on War-Acquired Tooling



Southwest Airmotive accessories technicians made this combination test stand for inspecting hydraulic fuel pumps, vacuum pumps and propeller governors

By **FRED W. ZELLMER,** *Southwest Airmotive Co. Maintenance Coordinator.*

Conservative but comprehensive program is planned to expand and modernize base's extensive overhaul and servicing facilities . . . All departments to benefit from improvement scheme designed to handle increasing tasks.



A corner of SAC's machine shop. Typical of company's equipment is 16-in. lathe (foreground). Behind it, a Buffalo drill press is being operated. Although shop was kept up-to-date during war, even more efficiency is planned through addition of much new equipment

IN THE '46-47 WINTER Southwest Airmotive at Love Field, Dallas, is thinking in terms of growth and progressive shop improvement, rather than of undertaking radical reconversion through a major retooling offensive

Southwest is in particularly good shape as regards new tools and shop equipment because the company was able, throughout the war, to get needed items. Our engine overhaul facilities were engaged by the AAF on a fixed-fee basis, and we were given priority on tools we needed to handle Ranger 175s and Lycoming 300s

Turning out as many as 15 completely rebuilt engines daily demanded use of complete and modern equipment. Because of a fixed-fee contract, we pur

Overall view of engine shop which handles major overhauls for private owners and airlines. All work is carefully scheduled and ship shape well lighted layout makes for top efficiency. Base is located at Love Field Dallas, Tex.

An aircraft radio receiver is tested (center) in Southwest's radio department. Large black unit in front of middle technician is a General 805-A signal generator acquired while concern was doing AAF contract work.

chased items outright and own and operate them today on a very active program servicing private owners and airlines.

However, this should not be interpreted as meaning that we are resting on our laurels and do not anticipate adding new equipment to that accumulated during the war.

Continuous Modernization

On the contrary, we recognize the fact that modernization must be handled on a continuous basis. This is particularly true at Southwest Airmotive, since this base is factory approved for a wide variety of engines, parts, and accessories, each requiring specialized handling. For instance, the engine shop now must be prepared to completely overhaul Pratt & Whitneys, Jacobs, Rangers, Lycomings, Warners, Wrights, and Continentals. The same applies in our accessories, instrument, radio, propeller, and aircraft shops.

Immediately after the war, we got into overhauling P&W R-1830s for Douglas C-47s and DC-3s (see page 48 Oct. AVIATION). To perform the job as the factory and CAA specified, we had to purchase thousands of dollars worth of special R-1830 tools. The first order—and there have been many since—called for 14 gages, 2 laps, 9 reamers, 3 taps, 27 wrenches, 2 adapters, 3 cutters, 2 drivers, 3 holders, 11 pullers, 4 arbors, 7 fixtures, 2 sleeves, 2 eyes, 4 bars, a clamp, a jig, and an indicator. In addition, we bought master rod assembling and disassembling tools, bushing line reaming jigs, a four-blade test prop (costing $1,000 second hand), and 10 engine stands for teardown and build-up.

And once more we are faced with a similar problem in the overhaul of P&W R-2000s. While we can, of course, use all of our major tools and machines on the R-2000s, we nevertheless must get specialized implements just as we did for the smaller power plants. We have ordered an R-2000 test prop, blower clutch testing rig, wrenches, and many other items for use just on this type engine.

We class as improvements, rather than as retooling, some $25,000 in new equipment which we now have on order and on which we expect delivery in the near future. Much of this is for the machine shop and is designed to save man hours, eliminate wastage (an important factor frequently overlooked), promote efficiency, and make us 100% self sufficient without recourse to outside shops to which we from time to time have had to sublet work. Included will be an 8-ft. power brake, 8-ft. steel shears, 8-ft. soft metal shears, radial drill, No. 2 universal milling machine and a tool grinder, 24- and 16-in. lathes, test stand, surface grinder, honing machine, piston ring lapper, propeller governor test stand, and another engine test stand. We have recently acquired and are now using a new steel cutting bandsaw and also a 26-in. DoAll bandsaw.

It is anticipated that a 50% increase in efficiency will be achieved with the radial drill in cutting out valve guides and seats and in working on sparkplug bushings, cylinders, and pistons. The universal miller will be used in automatic slotting, side milling, keying, and jig boring. The 24-in. lathe will be kept busy machining crankcases, bearings, crankshafts, and miscellaneous heavy work. Our surface grinder will be used on spacers, washers, aircraft repair work on retract cylinders, and reworking and fitting rings.

These tools, together with miscellaneous grinders, saws, rivet guns, etc., will augment existing equipment in the machine shop that includes: Heald No. 55 cylinder grinder, 16- and 9-in. lathes, Wells No. 8 bandsaw, Buffalo drill press, 2 small drill presses, an Omeo hydro borer, and an Arbor press. Incidentally, on the hydro-borer, work on rods now is completed in 5 min. as compared with 45 min. formerly consumed.

The engine shop proper utilizes a Delin drill, hydraulic press, honing machine, valve refacer, valve reseating equipment, and Magnaflux.

Guesswork Banished

In the neighboring accessories shop, a coil and condenser tester has been recently acquired. Installed during the war were: Stromberg flow bench for pressure type carburetors, Weidenhoff magnascope, generator and regulator test bench, combination hydraulic fuel pump, vacuum pump and propeller governor test stand (designed and built at SAC), a setup for reconditioning sparkplugs, a Magnacharger starter torque test stand, and a high voltage ignition harness tester. All are pre cision devices that save untold hours of guesswork and hand operations.

Layout for Instrument Work

Similarly, the air-conditioned instrument shop emerged from the conflict with these up-to-date items: Sperry universal balance fixture, an Ideal oscillating table, Ideal turn-and-bank test stand, 30-in. Meriam manometer, Pioneer bell jar and surface plate, Pioneer altimeter test stand, airspeed test manometer, L & R master watch cleaning machine, tachometer test stand, Strobotac, Crosby deadweight tester, Hamilton sensitive drilling machine, Stanley grinder and buffer, Delta drill press, and a variety of portable test boxes, including those for cylinder head temperature, tachometer, and all types of electrical instruments.

The Hamilton Standard-approved propeller shop is functioning smoothly with a 20-ton hydraulic press, 2 headstocks for checking blades, propeller test table, and a balancing stand. SAC ingenuity plus factory guidance served to develop a home-made grinding and buffing setup, test table, and angle twister.

One of the finest equipped of Southwest Airmotive's shops is the radio department, which performed outstanding work for the AAF during wartime. Equipment includes a Boonton Q meter, vacuum tube volt meter, secondary standard signal generator, Hewlett-Packard audio signal generator, General 805-A signal generator, also lathe, drill press, and grinder, plus a number of test jigs and SAC-built universal dummy antennas.

On order now is equipment needed for work on glide path and localizer, as well as advanced testing devices for VHF and UHF.

Time has been saved and workmanship improved in the radio shop by nearly all these items. For instance, alignment time was cut from 30 to 5 min. through use of the vacuum tube test meter. The small machine shop has more than paid for itself, with radio technicians having been specially trained to fill their own machining needs rather than refer them to the large machine shop on the floor below.

A large aircraft shop, constantly host to private and corporate aircraft from all parts of the continent, has made similar strides forward. Latest item is a new forklift. Also to be added are aforementioned metal shears.

Serving all departments will be a plating shop which currently is being inaugurated and for which full equipment has been under installation.

The plating work previously went outside the plant, occasioning delays and unnecessary expense.

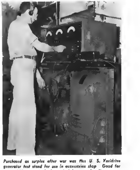
In considering tooling—or retooling—Southwest Airmotive's young executives have wisely included customer relations as one of the fields in which advancement can be made. And it has. Brand new is a 1946-model station wagon which will be used as a customer courtesy car. Then there are two mobile service wagons, one a two-decked baggage cart, the other a veritable four-wheeled "service station" which contains all the cleaning utensils necessary to brighten visitors' aircraft.

Lightplanes Fly Sales Missions

Sac's Sales Div., representing 45 parts and accessories manufacturers, likewise is in step, as proved by its purchases of a '46 pickup truck for deliveries in the Dallas area and of two new lightplanes for covering aviation sales missions over a 5 state area.

It has taken Southwest Airmotive more than 12 yr. and approximately $500,000 to ready itself for the present flying age in America. We by all means intend keeping apace of the fastest-moving industry in history. This doesn't merely mean retooling and being done with it, rather, it means retooling both in theory and in reality all the time—365 days in every year.

Prop blade gets working over in buffing-polishing department designed and built during war by Southwest Airmotive's airscrew technicians. This shop is maintained to conform with Hamilton Standard specifications. (Tom Collins photo)



Purchased as surplus after war was this U. S. Varidrive generator test stand for use in accessories shop. Good for up to 300-amp., it checks control boxes and voltage regulators.

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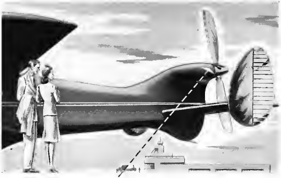


Why here?

Ever since the early days of aviation, the propeller on the nose of a tractor-type plane has subjected all surfaces behind it to the additional drag of the turbulent slipstream. Placing the propeller on the tail of the Waco *Aristo-craft* eliminates this drag.

Gone from the cabin are the customary propeller noises.

On the ground, elimination of "prop wash" allows plane doors to be opened easily . . . passengers may enter without walking into a "cyclone."

Last and far from least, the propeller is in the *safest* location on the airplane. Propeller accidents are virtually impossible with this arrangement.

That's why the Waco Aircraft Company has incorporated the "tail propeller" in its four-place *Aristo-craft* — the airplane with simplified uni control.

Waco Aristo-craft

WACO

THE WACO AIRCRAFT COMPANY, 1601 PETERS AVE., TROY, OHIO, U. S. A.

AVIATION'S MAINTENANCE NOTEBOOK

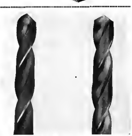
Battery-Fed Portable Spotlight Is Handy for Night Servicing

• Used for night inspection and maintenance, this portable light also serves to facilitate baggage loading and provide illumination for cabin entrance doors and stairs.

Unit consists of automobile headlight and metal case containing storage battery. Light tilts up or down, and handy switch is attached to handle.

Device, used throughout WAL's system, was developed by Joe Fogarty and Frank Eastman, maintenance division superintendent and station manager, respectively, at Denver.

Modified drill (left) for cutting stainless steel has cutting edge tapered to give rounded effect, in contrast to sharply pointed edge of conventional drill (right).



Though grind on modified drill (left) prevents appearance of radical departure from conventionally ground drill (right), cutting angles are equivalent (59 deg.).

Modified Drill Grind Utilized To Facilitate Work on Stainless Steel

• Recent modification involving reinforcement of nacelle stainless steel longerons posed a difficult problem at AOA's overhaul depot. Using longeron supports furnished by the craft manufacturer, overhaul personnel discovered that inaccessible longeron location did not permit use of spotwelding equipment, hence bolting supports to longerons was only alternative. But in cutting through stainless steel longeron with conventionally ground drill, it was found that too many man-hours were wasted; also, use of power drills, rotating at various speeds, proved unproductive. Problem was solved by AOA's John J. Brophy, who produced a specially ground drill—which not only cuts stainless steel, but stellite as well—to do the job in one hour. Details for modifying conventional type drill, to perform this operation, are:

(1) Two outer lips of cutting edges are rounded 1/16 in.

(2) Sharpening is done in conventional manner so as to give great amount of relief to cutting edge. Necessary amount of rake automatically follows—obtained by applying rolling motion to drill as it contacts grinding wheel.

(3) Cutting edge is ground closer to web than normally, in order to utilize drill strength at this point.

(4) Grinding rpm. of drill holder is regulated to afford slow turning of drill.

(5) Turpentine is used as an effective cutting agent.

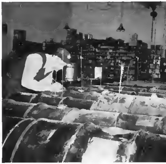
Without modified grinding, drill soon disintegrates by chipping and burning around points—hence necessity for cutting close to web when grinding for modification. Proximity of cutting edge to web affords maximum heat dissipation as well as maximum strength. As modified, drill assumes a radical appearance, but check reveals normal cutting edge of 59 deg.

Handy Spring Depressor Speeds Valve Work

• To facilitate the depression of valve springs, Duncan Perry of Seawings seaplane base, Westport, Conn., devised this depressor tool.

Lever has end drilled with four holes and is attached to right-angled fork via bolt through hole appropriate for cylinder size and make. With screwdriver as fulcrum passing through bushing at extreme end of lever, downward force causes fork prongs to depress spring for easy release or insertion of valve.

Mechanic Perry also devised the three units shown in Dec. '46 AVIATION at top of pages 55 and 56 and bottom of page 57.



Readily Visible Float Gage Gives Quick Liquid Check

• To measure liquid contained in 55-gal. steel drums stored in UAL's Cheyenne maintenance base warehouse, Assistant Storekeeper Donald W. Kerns devised this simple floating gage.

Used in container stored horizontally on rocker type stand, gage provides easy check on liquid content, eliminating possibility of inadvertently running out of any item, and speeding up inventory procedure. Device is estimated as saving approximately 265 man-hours yearly.

ROTARY WING AIRCRAFT

(Continued from page 63)

n-bladed rotors. At still greater relative speeds a singular speed range is encountered. In this range, operation may be smooth but a slight disturbance to the ship may cause it to vibrate (cause the hub center to whirl) with ever increasing amplitude. The oscillation demonstrates all the characteristics of a dynamic instability. Assuming that means are provided to limit the magnitude of the oscillation, its nature may be safely observed. It will be noted that frequency of the vibration is considerably lower than rotative speed; in order it more nearly approximates the natural frequency of the ship. The instability persists over a wide range of rotor speeds although its frequency shows a gradual rise as rotor speed increases. At the point of most severe oscillation, however, the vibration frequency coincides with the natural frequency of the aircraft.

The unstable oscillation degenerates to small magnitude at higher speed, and in the upper rotor speed range the rotor turns smoothly and with perfect stability. Type of vibration just described is the more vicious of the two associated with ground resonance and has been termed *odd-frequency* or *instability* vibration. Deriving its energy from the turning of the rotor itself, it is truly a "self excited" oscillation.

"Critical" rotor response can be controlled by installing extremely great damping capacity in the landing gear. As a practical measure, it is found preferable to provide the aircraft with a soft (low frequency) spring gear having moderate damping capacity, so that the critical response occurs only transiently as the rotor is accelerated or decelerated from normal idling speed.

Instability oscillation can be controlled by the provision of adequate gear damping and blade hinge damping. Damping should be effective in *both* locations if the oscillation is to be controlled or avoided.

Attention is directed to the excellent theoretical developments presented in Refs. 1 and 2 for the mathematical derivations applying to two-blade and multi-blade rotor systems. In the following discussion it will be the object merely to set forth the working formulas which apply to the singular characteristics of rotors subjected to isotropic pylon restraint.

Critical Speeds

Equation defining single critical speed of a rotor having three or more blades ($n \geq 3$) may be written

$$\left[(\omega_{y0}')^2 + \frac{a}{b\epsilon^2}(\Omega')^2\right]\left[1 - (\Omega')^2\right] - \frac{nm(\Omega')^2}{2(M + nm)\epsilon^2} = 0 \qquad (23)$$

Both ω_{y0}' and Ω' are given in terms of the reference frequency ω_r.

Equation defining the two critical speeds of a two blade rotor ($n = 2$) may be written

$$\left[1 - (\Omega')^2\right]\left[\left[1 - (\Omega')^2\right]\left[(\omega_{y0}')^2 + \frac{a}{b\epsilon^2}(\Omega')^2\right] - \frac{nm(\Omega')^2}{(M + nm)\epsilon^2}\right] = 0 \qquad (24)$$

It is apparent from the above equation that one critical speed occurs at the pylon frequency $1 - (\Omega')^2 = 0$. Corresponding state of whirl finds both blades extending in a straight line colinear with radius of whirl.

Lower critical speed is defined by second bracket of Eq. 24. At this speed blades are "V'd" toward outside of whirl, with whirl radius perpendicular to link joining the blade roots (Fig. 12).

Effect of blade damping or landing gear damping upon magnitude of undamped critical speeds is negligible for any reasonable value of damping. It is, therefore, an unnecessary refinement to add damping terms to Eqs. 23 or 24.

In Fig. 11, points C_1 and C_2 where $\omega_2' = 0$ correspond to the lower and higher values for critical speeds of the two-blade rotor. In Fig. 10, point C corresponds to the single critical speed of the three (or more) blade rotor.

References

1. *Theory of Self-Excited Mechanical Oscillations of Hinged Rotor Blades*, by Robert P. Coleman. NACA ARR No. 3G29, July 1943.
2. *Theory of Mechanical Oscillations of Rotors With Two Hinged Blades*, by Arnold M. Feingold. NACA ARR No. 3I13, Sept., 1943.
3. *Response of Helicopter Rotors to Periodic Forces*, by Bartram Kelley. NACA ARR No. 5A09, Mar., 1945.

REVIEW OF PATENTS

Following are digests and listings of some of the more interesting patents on aviation developments granted through the U. S. Patent Office. Printed copies of any of these patents are obtainable directly from U. S. Patent Office, Washington, D. C., at a cost of 25¢ each.

Electrical Connector comprises body portion and movable contact equipped with U-shaped spring retainer. Spring engages flattened portion of contact so that latter upon sufficient rotation to disengage spring may be removed from body portion of connection.—2,411,[illegible], filed Mar. 19, '43, pat. Dec. 3, '46. C. Antony, Jr. and E. J. Isbister, assignors to Sperry Gyroscope Co.

Servo System embodies motor coupled to a.c. generators for supplying outputs of same frequency in substantially 90 deg. phase relationship, also two-phase motor with fields excited by potentials respectively derived from generator outputs and thermionic means adapted to receive reversible phase input and to supply reversible polarity continuous proportional output for exciting at least one of generators to control magnitude and direction of torque exerted by two-phase motor.—2,411,871, filed Nov. 2, '42, pat. Dec. 3, '46. G. de Westfelt, assignor to Sperry Gyroscope Co.

Turbojet Nozzle Control incorporates adjustment means to obtain diffuser action in combination with other means for adjusting nozzle to obtain predetermined operating characteristics in turbine. Also included is pressure responsive device for automatically rendering inoperative first adjusting means when second means becomes operative.—2,411,[illegible], filed Apr. 15, '44, pat. Dec. 3, '46. D. M. Toole, assignor to United Aircraft Corp.

Airplane Air Conditioning Apparatus combines liquid fuel-burning heater, ram for combustion air, supercharger, and conduit leading from supercharger to ram for conveying compressed air to heater. Valve is incorporated to shut off ram, while another valve is used to close conduit, these two valves operating so that one is opened when other is closed.—2,412,110, filed Feb. 4, '43, pat. Dec. 3, '46. L. A. Williams, Jr., assignor to Stewart-Warner Corp.

Hydraulic Transmission Device includes fluid-type housing having driving impeller at one end in predetermined spaced relation to driven rotor at other end. Pressure responsive means for varying space between these members comprises plurality of L-shaped vanes each with plurality of springs for urging inward extending leg of vane toward impeller, displacement being variable to compensate for differences in impeller speeds without imparting consequent changes in rotor speeds.—2,411,772, filed Aug. 22, '44, pat. Nov. 26, '46. J. S. Becker, assignor to Bendix Aviation Corp.

Autogiro features rotor mounted at end of each wing and means for rocking rotors transversely from operative position to one of rest in which a portion of rotor is received in wing recess, with remaining portion extending beyond wing.—2,411,[illegible], filed Jan. 27, '44, pat. Nov. 19, '46. A. Nerna.

Airspeed Indicator is adjustable to fuselage with front end disposed clear of propeller stream and so deep vertically as to be substantially unaffected by air disturbances such as those which affect wing leading edge with changes in angle of attack. Dynamic head is located near midheight of fuselage front end and static head is placed in each side of fuselage.—2,411,484, filed June 9, '44, pat. Nov. 19, '46. M. Watter, assignor to The Budd Co.

Other Patents

Sleeve Valve Engine, 2,411,[illegible], filed Jan. 22, '44, pat. Nov. 26, '46. R. M. Heintz, assignor by mesne assignments to Jack & Heintz Precision Industries.

Transport Plane, 2,412,[illegible], filed Oct. 20, '42, pat. Dec. 10, '46. G. W. Peck, assignor to Howard W. Taylor.

Aircraft Brake, 2,412,[illegible], filed Aug. 9, '41, pat. Dec. 10, '46. B. E. House, assignor to Bendix Aviation Corp.

Aircraft Control Surface, 2,411,[illegible], filed Aug. 27, '43, pat. Nov. 12, '46. H. L. Pitt.

Adjustable Harness Clip, 2,409,[illegible], filed May 13, '44, pat. Oct. 22, '46. C. Laud, assignor to Adel Precision Products Corp.

The Department Foreman (right) consults with a Gulf Lubrication Engineer on the performance of Gulf Cut-Aid in machining a brass part. *(Photos courtesy of the Corbin Screw Division of American Hardware Corporation.)*

Aviation People

Beverly E Haward (photo) pres of Hawthorne Flying Service, has been elected pres of National Aviation Trades Assn. During war his army contract school at Hawthorne Field trained American and French cadets for AAF. He is a member of CAA's Non-Scheduled Flying Advisory Committee and a director of All American

B. E. Haward J. H. Carey

Aviation. His precision acrobatic flying won him this year's National Aerobatic Championship. **John H Carey** (photo) has been appointed acting deputy administrator for Office of Aircraft Disposal of WAA. He learned to fly in '18 with British RAF, and has been active in aviation since. During war he served as chief of staff, Army Air Service Command with 15th Air Force in Mediterranean theater. He is a member of N. Y. Aviation Post, American Legion.

John Friedlander (photo), pres. of Aeronca was appointed chairman of Personal Aircraft Council of Aircraft

J. Friedlander G. Sleeper

Industries Assn, succeeding **William T Piper. Gordon Sleeper** (photo) personal plane sales mgr for Republic was elected vice-chairman succeeding Friedlander.

A L Riggs (photo) returned to prewar post as gen. sales mgr for Waco Aircraft. A veteran of 13 yr in aviation he entered Troop Carrier Command

A. L. Riggs H. Crary

during war as a service pilot and served as an instructor on C-46 and C-47 planes and Waco CG-4A gliders, and later was commander of 332nd Troop Carrier Squadron. **Harold Crary** (photo), v.-p. in charge of traffic and advertising for UAL, was appointed to serve as chairman of AIA's advertising committee for '47. He joined airline in '31 when it was formed, and previously was director of advertising and publicity for Boeing. **John B Goodman** has been appointed asst. to mgr. of publicity at UAL's Chicago hq. **W. H Maxwell** has been made asst. to vice-pres.-eastern operations with Chicago hq., **William S. Wallace** has been appointed supt. of eastern regional ticket office and **J. S. Keakin** has been named western region ticket office supt. Also **M P Bickley**, mgr. of cargo sales, has been named chairman of newly-formed cargo sales promotion committee of ATA. And **G. T. Kelloff** has been appointed, district publicity representative at Wash. hq., while **Paul Reed** was named station mgr. at N. Y. hq.

B G Reed (photo) was elected v.-p. in charge of manufacture for Northrop. He will supervise output of three-engine Pioneer and oversee manufacture of military contracts including B-35 Fly-

B. G. Reed Lt. Col. Ryan

ing Wing and Reporter F-15, photo reconnaissance plane. He has been associated with company since '34. **Lt. Col. Lloyd F. Ryan** (photo) is newly-

★ COMING UP ★

Jan. 6-10: Society of Automotive Engineers Annual Meeting, Book Cadillac Hotel, Detroit.

Jan. 6-15, '47: Aviation of Tomorrow Exhibit, Miami.

Jan. 10-12: All American Air Maneuvers, Miami, Fla.

Jan. 14: IATA Australian Traffic conference.

Jan. 27-30: Fifteenth annual meeting IAS, New York City.

Feb. 1-8: New York Aviation Show, Grand Central Palace.

Feb. 1-28: Inter-American lightplane cavalcade, Brownsville, Panama.

Feb. 8-9: Women's Aviation Convention, San Antonio, Tex.

March, '47: IAS Aircraft Propulsion Meeting, Cleveland, Ohio.

Apr. 18-27: Michigan Aviation Week, sponsored by Aero Club of Mich., Detroit.

May 9-17: Air Fair, sponsored by Aviation Council of Metropolitan St. Louis.

May 11-15: American Airport Exposition & Exhibit, in conjunction with Annual Convention of American Assn. of Airport Executives, Sherman Hotel, Chicago.

May 26-27: Light Aircraft Meeting, Detroit.

appointed supervisor of engineering laboratories at **Ryan**. He was recently released from **AAF** after 5 yr as a research physicist at Air Materiel Command Wright Field, and as an intelligence officer, under personal orders of **Gen Arnold**, on special investigations of enemy technical developments **Harold W Hasenbeck** has been named supervisor of electronics and control systems research at Ryan and will head company's special military projects laboratory

Col. E Verne Stewart (photo), formerly chief of Army parachute branch, Wright Field, has become director of product development for Pioneer Parachute Co., in which capacity he will supervise research developing, experimenting and testing of parachute and accessory equipment He is a member of Caterpillar Club and a licensed CAA parachute rigger. **Gerry W. Hawes, Jr.** (photo) has been appointed eastern regional director of state affairs for AA Graduate of University of Minnesota, he has been with airline since 35 and has served in various branches as sales mgr (Del Ankers photo). **David Marshall** has been appointed asst. to director of pub rel for AA

Col Stewart G W Hawes, Jr.

Robert E Weiland Jr. has been appointed representative for National Airlines at Cuba

Braniff appointments **W. R. Beattie** has been named gen traffic mgr Latin American div, **Paul D. Niles** has been appointed gen traffic mgr of domestic div, **Douglas Wood** was named interline and foreign sales mgr, **Stanton Fitzner** was appointed publicity asst., and **I. H Powers** has been named district traffic mgr in Chicago

W. R Mareland has resigned as MOA's pub rel director

Harrison H. Boyd has been appointed local mgr for NEA at Lawrence Municipal Airport

Bill Ross has been named news bureau mgr for PCA

Cyril C. Thompson, former v-p UAL, has been appointed special representative air transport, for Santa Fe Railway System

W Moscrip Miller, resigned as v-p in charge of pub rel. for Air Cargo Transport, will now head a newly organized pub rel group bearing his name

TWA annual aviation writing and photographic contest winners Newspaper, open class—First prize, **James J. Strebig**, aviation editor, Associated Press; second **Reginald Cleveland**, New York *Times*, tied for third, **Gene Dawson**, Indianapolis *News*; Robert Menotsier, New York *Sun* and Ned Aitchison, Miami *Herald*. Newspapers under 100 000—First, **Albert I. Prince**, Hartford *Times*, second Nick Moser, Reading *Eagle*; third **Edgar Bauman**, New York, free lance aviation columnist. Magazines—First, **John Paul Andrews** New York *Air News*, second **Wayne Parrish**, *Liberty*, tied for third **Fred Hamlin**, *Flying*, **Eric Bramley**, *American Aviation*, **Lucien Zacharoff**, *Air Trails* Technical—First, **Arthur Harris**, *Aviation Maintenance & Operations* second **Oscar Leiding**, *Air Transport*, third, **Irving Stone**, AVIATION Photo—First, **Howard Ballew**, Los Angeles *Herald Express*; Second **A Aubrey Bodine**, Baltimore *Sun*, third **Elear G Chindmark**, Hartford *Times*.

Robert B. Kinkead, of Boeing was elected chairman of Export Comm of Aircraft Industries Assn **A. M. Gonnella** has been named asst. chief sales engineer for Boeing.

Recent Books

HUMAN FACTORS IN AIR TRANSPORT DESIGN, by Ross A McFarland, McGraw-Hill Book Co., New York City Illustrated, 670 pages $6 00

This book analyzes those factors in air transport plane design which influence the human organism in flight Special attention has been given to recent advances in all fields of human biology which are applicable In all cases the implications of theoretical material have been developed and the application to industry and the needs of engineers carefully brought out This work is an unusually complete compilation and interpretation of biological data which the aeronautical science can use to improve the efficiency of air crews and safety and comfort of air travelers.

THE AIRCRAFT MECHANIC, by Philip Siegel, Pitman Publishing Co., New York City. Illustrated, 313 pages $4 00

A manual for certificate candidates This book is divided into six chapters It thoroughly covers the CAR's techniques and practices, propellers, hydraulics rigging and assembly wood and fabric covering sheet metal riveting, welding, soldering and finishing Each section is arranged so that review questions pertaining to it follow immediately after each chapter's text Most questions are of the multiple-choice type used in the actual examination Answers are given for all sets of questions

METALLIZING HANDBOOK (Fourth Edition), Published by Metallizing Engineering Co., Inc., Long Island, New York Illustrated, $2 00

Latest in technical and operating data on metallizing is contained in this handbook Details including preparation of surfaces metallizing techniques and finishing procedure corrosion resistance, specific gravity hardness bond strength tensile strength and relative shrink are covered.

TRIGONOMETRY REFRESHER FOR TECHNICAL MEN, By Albert Klaf, McGraw Hill Book Co., New York City. 629 pages $5.00

This work by the author of *Calculus Refresher*, concisely explains the problems of plane and spherical trigonometry Treatment is especially useful to men who wish to apply trigonometry to various technological fields

THE WORLD S WINGS by Lucien Zacharoff, Duell, Sloan & Pearce Inc, New York City. 310 pages $3 00

This volume surveys the international scene studies the conferences the plans of the great nations to win airways control the men and the motives involved It then concludes with a plea for public awakening against a course toward war The author offers an international policy aiming to counter air imperialism and develop action for peace

PRESENTING—
New Construction

Here is a new, regular AVIATION feature keyed to new construction in the aeronautical industry, giving in concise form a collation of new projects in all phases of the business.

Reports under each major type of work classification are grouped by stage of work proposed, bids asked, and contracts awarded. Projects under each stage are listed alphabetically by states, then alphabetically by city or town.

AIRPORTS & AIRBASES

CONTRACTS AWARDED

Calif. San Mateo—AIRPORT—Bay Meadows Aviation Co. Bell St. and Pacific Blvd. airport incl 4400 ft runway 100 ft. wide Owner builds. $500,000 D D Stone & L. B Mulloy, 681 Bush St., San Francisco assoc archts.

Ill., Springfield—AIRPORT BLDG—Springfield Airport Auth 307½ S 6 St. reconstructing 51x218 ft warehouse serving as temporary terminal bldg. to Felmley Cobalt Co. Peoples Bank Bldg Bloomington. Approx. $74,000 Awarded 12/2

N. J., Ocean City—AIRPORT—Seacoast Airlines, Inc Ocean City airport addns. imprv incl hangar separate contracts. Over $40,000

PROPOSED WORK

Ala. Montgomery—AIRPORT BLDG—City, c/o City Com. plans by Pearson & Tittle First National Bank Bldg. administration bldg. at municipal airport. $280,000

†Ariz. Davis Monthan Field (P. O. Tucson)—HOUSING—U S Eng. 751 S. Figueroa St. Los Angeles 55, Calif. military housing at airfield $318,000

★Ariz., Phoenix—AIRPORT—City Phoenix voted bonds imprv Sky Harbor Airport $1,100,000.

†Ariz. Williams Field (P. O. Chandler)—HOUSING—U S Eng. 751 S Figueroa St Los Angeles 55 Calif. military housing $267,000

†Calif. Mather Field (P. O. Sacramento)—HOUSING—U S Eng. 1209 Eighth St. Sacramento Zone 2 military houses at air field $225,000

†Calif. Riverside—HOUSING—U S Eng 751 S. Figueroa St Los Angeles Zone 55 military housing at March Field $1?6,000

†Colo. Denver—HOUSING—U S. Eng 509 17 st Zone 2 military housing at Lowry Field $162,000

†D. C., Bolling Field (Wash. D. C. P. O.)—HOUSING—U S Eng. 1 and Douglas Sts. Wash 25 D C, military housing at airfield $140,500.

†Fla. MacDill Field (br Tampa)—U S Eng Post Office Bldg. Savannah Ga. military housing at airfield $162,000

†Fla. Orlando—HOUSING—U S Eng. P O Bldg. Savannah Ga. military housing Orlando Field $162,000

Ga. Milledgeville—HANGARS etc.—Southern Airways Inc Municipal Airport Hapeville 2 hangars and dormitory $300,000. Financing provided

†Ill., Chanute Field—HOUSING—U S Eng. 222 N Bank Dr Chicago Zone 14 military housing at airfield $290,000

†Kan., Salina—HOUSING—U S Eng 16 E 17 St Kansas City Zone 6 Mo. military housing at Smoky Hill Airport. $270,000

†Me., Bangor—HOUSING—U S Eng 31 St James Ave Boston 16, Mass military housing at Dow Field. $211,000

Mass. Fall River—AIRPORT—Fall River Airport Comm Fall River plans under way municipal airport incl two 3,700x300 ft landing strips two 3,500x150 ft. paved runways, etc $650,000 Fay Spofford & Thorndike 11 Beacon St Boston 8 consult engrs

†Mass. Westover Field (Chicopee Falls P. O.)—HOUSING—U S Eng. 31 St James St Boston Zone 16 military housing at air field $405,000

ABBREVIATIONS & SYMBOLS

★ Projects $1,000,000 and more in value.
† Federal Government projects.

What's New

(Continued from page 13)

lights of 1,965 000 cp each. Auxiliary transformer equipment is optional to boost each light to 3,225 000 cp. Combination models have two 16-in floodlights and two 18-in searchlights. Beacon models, for special directional applications have one 24-in 11,280 000 cp searchlight.

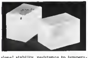
Riveting Kit 17

Consisting of three standard shanks—suitable, respectively, for light and heavy duty pneumatic riveting hammers and for hand riveting with a

mallet—new riveting kit, No 1123 is made by **Aero Tool Co.**, Burbank, Cal. Interchangeable cup-forged rivet set cups are provided to accommodate round head (AN430), brazier head (AN455), and modified brazier head (AN456) rivets. Rivet diameters range from 1/16 to ¼ in. All parts are cadmium plated.

Relay Covers 18

Made of polyester-type contact pressure resins, and reinforced with Fiberglas milled fibers, new covers for dust and moisture protection on aircraft electrical relays are announced by **Master Plastics, Inc.**, Wilmington, Del. Covers were developed to give dimen-



sional stability, resistance to temperature change and to fairly high temperatures and to have high elasticity and impact strength. They are stated to have a temperature resistance of more than 300 deg. F.

★ Information Tips ★

ENGINEERING DATA

Babbitt Bearings 19

Instruction card "How to Pour Bearings", issued by **Joseph T. Ryerson & Son**, Chicago, is a series of six cartoon type pictures illustrating steps necessary in making good babbitt bearings.

Induction Heating 20

Containing charts, graphs and technical data, new bulletin from **Tocco Div., Ohio Crankshaft Co.**, Cleveland, Ohio, covers general history, principles and applications of induction heating.

Aluminum Alloys 21

Incorporating a section to explain to non-technical readers basic principles of metallurgy and heat treatment of aluminum alloys, new booklet, "Heat Treating Aluminum Alloys", available from **Reynolds Metals Co.**, Louisville, Ky., for $1.00, contains tables of recommended thermal treatments for various aluminum alloys, also discussion of various treatments.

Photographic Recording Material 22

Entitled "Kodak Recording Materials", new booklet published by **Eastman Kodak Co.**, Rochester, N. Y., describes photographic recording materials for use with cathode ray tube oscillographs, galvanometer oscillographs and similar equipment and contains information on processing procedures, equipment and materials.

PRODUCTION

Resistance Welding 23

Bulletin No. 88A from **Ampco Metals, Inc.**, Milwaukee, describing line of resistance welding electrodes and alloys, includes information covering water-cooled electrode holders, spotwelder tips and seam welding wheels.

Wire Stripping and Soldering 24

Division Lead Co., Chicago, announces new series of bulletins, 1A through 4A, describing chemical wire strippers, rosin core solder and rosin fluxes.

Needle Bearings 25

Article describing use of needle bearings in small helicopter is contained in Vol. 8, No. 5 of "The Bearing Engineer" from **The Torrington Co.**, Torrington, Conn.

MACHINERY & ACCRSSORIES

Spray Booth 26

Available in the following sizes: 5,000, 7,500, 12,500 and 15,000 cfm., new water tube spray booth covered in catalog from **Newcomb-Detroit Co.**, Detroit, is water curtain type and incorporates rise of series of tubes to clean paint-laden air.

Flexible Shaft Tools 27

Folder from **Wyzenbeek & Staff**, Chicago, describes line of flexible shaft tools for grinding, buffing, filing, sanding, and light drilling.

Parts Inspection 28

Literature from **Engineers Specialties Div., Universal Engraving & Colorplate Co.**, Cleveland, Ohio, describes "Pani-O-Jector", instrument for measuring and comparison of turbine and compressor blades by optical projection method.

ELECTRICAL

Connectors 29

Specifications and engineering and application data on terminals, links and quick-disconnect connectors are contained in new catalog covering line of "Hydent" electrical connectors made by **Burndy Engineering Co.**, New York City, for conductor sizes from No. 22 to 2,000 mcm.

PLANT SERVICE

Color Conditioning 30

Describing research and experience with color to increase production, improve seeing conditions and create better working environment, new booklet, "DuPont Color Conditioning for Industry", published by **E. I. duPont deNemours & Co.**, Wilmington, Del., discusses fundamental principles on which color conditioning is based.

AIRCRAFT & ACCESSORIES

Flying Aids 31

Series of bulletins issued by **Lear, Inc.**, Grand Rapids, Mich., describe "Learor", an integrated installation of aids to flying. It comprises electropilot, dual automatic radio compass, VHF transmitter and receiver, VHF omnirange converter, marker beacon receiver, glide path receiver, and antenna systems.

Propellers 32

Designed for transport aircraft using 800 to 1,900 hp., hydraulic operated propeller Model A422F is described in new bulletin from **Aeroproducts Div., General Motors Corp.**, Dayton, Ohio, which contains general description, principles of operation, construction and specifications.

Aircraft Floats 33

Containing articles on use of floats on small personal planes, Vol. 1, No. 3 of "The Flying Fish", published by **Edo Aircraft Corp.**, College Point, N. Y., also describes new Navy scout plane made by company.

Number Stencils 34

Catalog page from **E. W. Wiggins Airways**, Norwood, Mass., describes new stencils for putting a contrasting border around NC numbers on aircraft.

AIRPORTS

Signal Light 35

"Flash-A-Beam" is new traffic control light described in folder from **Diller Electric Mfg. Co.**, Kokomo, Ind., which also gives outline of light-signal procedure.

Refueling Unit 36

Powered with a 7.7-hp. air cooled gasoline engine, new mobile aircraft refueler "Chore Boy", described in literature from **Buda Co.**, Harvey, Ill., holds 250 gal. and is 133½ in. long, 40 in. wide and 53½ in. high. Weight is 2,300 lb.

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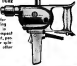

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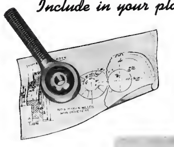

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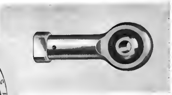
Illustrated at right is the Heim Unibal Spherical Bearing Rod End.



The illustration above is the rugged Unibal Spherical Bearing.

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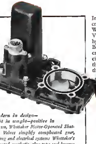

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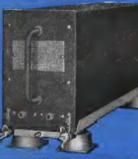

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